THE ENGINEER

AUGUST 15, 1952

Electricity Consumption in Britain

FIGURES published recently by the British Electricity Authority show that there is a downward trend in electricity consumption. For every month since February last there has been a decrease in the number of units sold by the Authority and in the number of units sent out by many of the Area Boards, compared with the corresponding month last year. If allowance is made for the differences in the number of working days and in weather conditions, the adjusted national sales for each month show a slight increase over those of the previous year. For example, the adjusted sales in June, 1952, were 1·4 per cent more than those in June, 1951. Nevertheless, the real trend of consumption is noticeably downwards. Thus, in April, 1951, the adjusted sales were 11 per cent higher than in April, 1950; but by 1952 the rate of increase over the corresponding month of 1951 had fallen to 3·6 per cent in April, 2·9 per cent in May and to only 1·4 per cent in June. An analysis of the records of electricity sent out to consumers by the Area Boards, if the totals for June, 1952, are compared with those for June, 1951, show that eight Boards recorded increases, as follows: London, 0·6 per cent; South-Eastern, 2·1 per cent; Southern, 8·8 per cent; South-Western, 3·7 per cent; Eastern, 4·1 per cent; South-East Scotland, 3·8 per cent; South-West Scotland, 2·1 per cent; South Wales, 5·4 per cent. It is significant that, with the single exception of South Wales, these Area Boards have mainly non-industrial consumers. In the remaining Area Boards, which serve mainly industrial areas, the sales for June, 1952, were less than those for June, 1951, by the following percentages: East Midlands, −2·0 per cent; Midlands, −0·2 per cent; Merseyside and North Wales, −4·5 per cent; Yorkshire, −1·7 per cent; North-Eastern, −5·1 per cent; North-Western, −7·5 per cent. The decline in the sales in the North-Western area is clearly associated with the recession in the Lancashire textile industries. On the other hand, the increases recorded by the Southern and South Wales Area Boards are attributable in part to the demands made respectively by the new oil refinery and steel works loads.

Economics for Engineers

FOR some time there has existed a liaison between the Imperial College of Science and Technology and the London School of Economics and Political Science for the encouragement of post-graduate studies on subjects likely to interest students of both bodies. That liaison has now been placed upon a more permanent basis. The College and the School have now decided to collaborate in encouraging research which will throw light on the direction, strength and interplay of scientific, technological, social and market forces. Post-graduate research students accepted by either the College or the School for this type of work will receive guidance and help from both schools and, where advisable, the student will be placed under two supervisors, one at each school. In addition, arrangements have been made to assist post-graduate students of either body whose purpose is to broaden and deepen their education and training, rather than to engage in research. Students of Imperial College who have been accepted for a post-graduate course in science or technology and who wish to acquire an introductory knowledge of such subjects as economics, law, history and administration will be afforded facilities to do so at the London School of Economics. Similarly, the Imperial College will provide for students of the London School special courses designed to illustrate typical developments in science and their application to industry and to give the student some acquaintance with industrial materials and products, manufacturing processes and equipment. Further information is obtainable from the registrars of the Imperial College, Prince Consort Road, London, S.W.7, and of the London School, Houghton Street, London, W.C.2.

Foundation Stone Laid at Doncaster Works

LAST Thursday, August 7th, an interesting ceremony took place at the Doncaster works of the International Harvester Company of Great Britain, Ltd. The foundation stone of a large extension was laid by Mr. John L. McCaffrey, president of the International Harvester Company. The new structures, estimated to be completed and in service within about eighteen months will add 32,912 square feet of space to the foundry and 125,324 square feet of space to the tractor building. Some 1000 additional employees will need to be taken on and many of them will have to be specially trained for the work. Mr. Schmidt, works manager of the British Company, acted as chairman during the ceremony, and amongst those who spoke were the Mayor of Doncaster, Councillor Hubbard, and Mr. McCormick, managing director of the British company. After Mr. McCaffrey had wielded the trowel and laid a foundation stone bearing the inscription "Dedicated to a Quality and Service by John L. McCaffrey, President, International Harvester Company, 7th day of August, 1952," a number of documents were placed in a leaden casket to be embedded in the foundations of the new building. These documents included copies of national and local newspapers and farming, farm machinery and engineering periodicals, literature about the Doncaster products of the firm, the house magazine, annual reports for 1951 of the British and American companies, a booklet recording the story of the company's early beginnings in Great Britain—one of its products was shown at the Great Exhibition of 1851—records of the building and re-capitalisation scheme and a copy of a sound/colour film "Romance of the Reaper," which tells how Cyrus H. McCormick, founder of the company, designed and built the first practical reaper in 1831. Our editor was present and had the honour and pleasure of placing a copy of the issue of THE ENGINEER for August 1, 1952, in the casket.

Fire Research, 1951

HER MAJESTY'S STATIONERY OFFICE has published on behalf of the Department of Scientific and Industrial Research and Fire Offices' Committee, "Fire Research, 1951," which is the report of the Fire Research Board. It contains a study of the outbreaks of fire, giving a review of the various causes, together with a tabular statement which states that the average yearly incidence of large fires over a seven-year period was 170, representing a loss of £7·25 million. Of the 72,000 fires attended by fire brigades it is considered that 35,000 were avoidable. Further work has been carried out concerning the initiation, growth and suppression of fire and the behaviour of materials in fires, and the investigations have touched upon the kinetics of smouldering, the inflammability of gases and the mechanism and products of flame suppression. Continuing previous radiation experiments, the protection afforded by paints has been tested and also the ignition of textiles, while a graph shows the intensity of heat radiation from a building on fire. The study of the growth of fire by means of models has gone forward and the comparison of temperature records of model and full-scale houses is given. An apparatus has been constructed to examine the effect of a water spray on a kerosene fire and a theoretical study undertaken of the absorption of radiation by water sprays, while further experiments have been carried out on the behaviour of foams under practical conditions. Another section of the report discusses the structural aspects of fires in buildings; further work on the surface spread of flame has been carried out and the fire resistance of prestressed concrete studied, the application of plaster as a protection being stated to be important. Work on special fire hazards has proceeded during the year and includes fires caused by dust explosions and the combustion products of plastics. Tests have shown that there is no reason to expect a dangerous release of poisonous gases at fires involving plastics.

Centenary of Mining Institute

LAST month marked the hundredth anniversary of the formation of the North of England Institute of Mining and Mechanical Engineers, which, although formed after the Manchester Geological Society, is the oldest of the Mining Institutes which federated to form the Institution of Mining Engineers. The headquarters of the Institute, which contains a magnificent library housing a unique collection of mining literature and a commodious lecture theatre, are at Neville Hall, Newcastle upon Tyne. In celebration of the event, a centenary brochure has been published containing a list of the presidents, a short history of the development of mining and of the work of the Institute, and a copy of Charter of Incorporation granted by Queen Victoria dated November 28, 1876. In the brochure, the notes on mining recall the "bell pits" method of extracting surface coal practised in the thirteenth century, and the development of the bord-and-pillar system of working from the room-and-pillar method established by the end of the seventeenth century. Other developments recorded include the use of cast iron tubbing for shafting, early ventilation systems, the invention of the Davy lamp, and the move to secure increased safety in coal mines which led to the founding of the Institute. The association of the first president, Nicholas Wood, with George Stephenson is recalled, and also that early members were largely instrumental in founding what is now King's College. The centenary will be celebrated by a special meeting to be held at headquarters on September 22nd and 23rd, at which a series of papers will be read, and mining exhibits will be on view at the University School of Mines, King's College.

Seaweed Research Annual Report

THE 1951 annual report of the Institute of Seaweed Research recalls that the Scottish Seaweed Research Association was formed in 1944, and that when the Government undertook sole financial responsibility on June 30, 1951, the Association was dissolved and was superseded by the Institute of Seaweed Research. The first two years were spent in establishing that a sufficiency of seaweed existed to support an industry, and since 1946 wider investigations have been completed, and the report states that a new programme has been formulated. This is concerned with the expansion of the work in ecology, algal chemistry and engineering as applied to harvesting seaweed and to producing seaweed chemicals. Although the two research vessels work mainly in the Firth of Forth area, the out stations at Oban and Kirkwall are being maintained and two vessels on charter have continued to investigate Scottish sub-littoral resources. The report gives details of the sub-littoral seaweed survey with notes upon mariculture and recolonisation.

New Jersey Turnpike, U.S.A.

No. II—(*Continued from page* 199, *August 8th*)

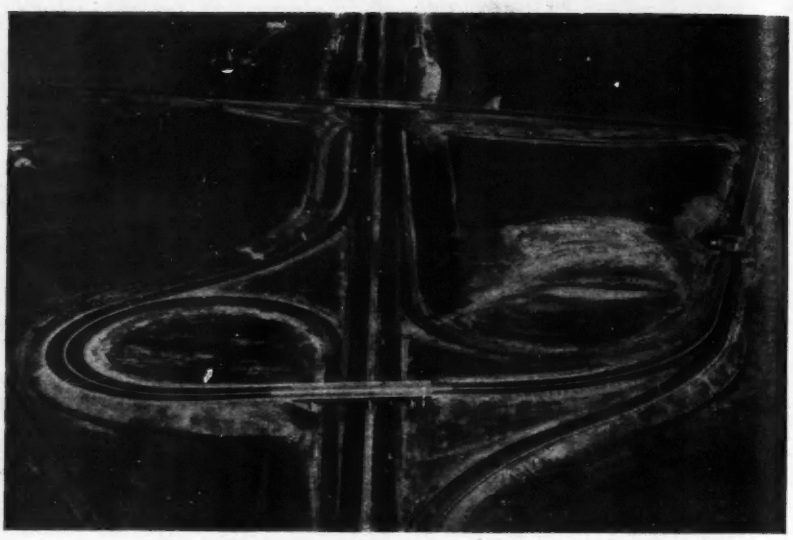
With the opening to traffic on January 15th of the final 9 miles of the 118 miles long New Jersey Turnpike, one of the most important highway construction schemes in the United States has been completed. It is of particular interest to note that the entire project, which involved construction costs of 213,000,000 dollars, was completed within only two construction seasons. The design and construction of the highway and of two major bridge structures are described.

Fill Stabilisation

A LONG section at the northern end of the turnpike was designed to traverse the low tidal flats and marshes known as the New Jersey Meadows. This route was chosen to avoid heavily built-up industrial and residential areas in Newark, public institutions in Hudson County, a second crossing of the Hackensack River, and other residential areas. The meadows are a geological formation consisting of deposits of mud and silt with a high water content, varying in depth from a few feet to 250ft. During the preliminary and design studies for the northern part of the turnpike, approximately 800 test holes ranging up to 212ft in depth were made to obtain samples for analyses of the more than 40,000,000 cubic yards of marsh mud encountered. Because of the variation in the character of the mud deposits, about 18,000 samples were tested for moisture content or density in order to classify the various strata. About 350 representative samples were tested for consolidation and permeability, and 175 for strength by tri-axial methods at various stages of consolidation. The studies of these tests, supported by past experience, indicated that it would be necessary to stabilise about 20,000,000 cubic yards of mud and soft silt and clay to obtain rapid consolidation and settlement of the roadway embankments in the short period allowed for construction. Previous work for the New Jersey State Highway Department had proved the efficacy of consolidation and stabilisation of sub-surface material by the use of vertical sand drains. It was decided, therefore, that the sand-drain method of consolidation could be used successfully for the construction of the turnpike across the meadows.

In general, consolidation of the marshes was obtained in accordance with the following procedure :—To check the rate of stabilisation during construction and to measure the amount of fill actually deposited for contract payment purposes, 1660 settlement platforms were installed before the sand fill blanket was placed. These platforms consisted of either a timber or a steel plate rectangle, approximately 3ft by 3ft. To each platform a pipe was attached which extended upward through the fill. Extensions to this pipe were added as the fill was built up. At various elevations in the mud foundations, 450 pore-pressure-indicating devices were set up so that the effect of the fill load on the underlying strata could be closely watched. In addition, about 500 control stakes were placed at the sides of all fills, and in the meadows some distance from the toe of the fill, to indicate any sideways movement.

A sand blanket 3ft or more in depth was placed on the surface of the meadow. The material for such a blanket had to be a free-draining sand containing a minimum of fine particles. With pile-driving equipment, a closed-end mandrel, from 14in to 20in in diameter, was driven through the working table, the sand blanket and the underlying meadow material to a firm stratum. One of the sand-drain rigs, comprising a pile-driving hammer and an attached elevating sand hopper, is shown in the accompanying illustration. Once the mandrel had been driven, it was filled with sand and then gradually withdrawn while the sand was pushed out through the opened bottom of the mandrel by air pressure applied on top of the sand. Thus the air pressure held the sand in place in the hole while the mandrel was withdrawn. The sand-drain material was required to be free draining in character, even coarser than the sand blanket, but containing no large particles. Through these sand drains the water in the underlying material percolated upward to the sand blanket as is shown in the diagram below. The depth to which the sand drains should be driven, and the amount of settlement to be expected in the underlying material, were estimated from previous sub-surface explorations, including soil samples taken at several levels. The depth to which the sand drains should be driven was again checked during the driving, and inspectors were instructed to have the driving continued until a specified number of blows per foot was required for further penetration.



Burlington—Mount Holly Interchange

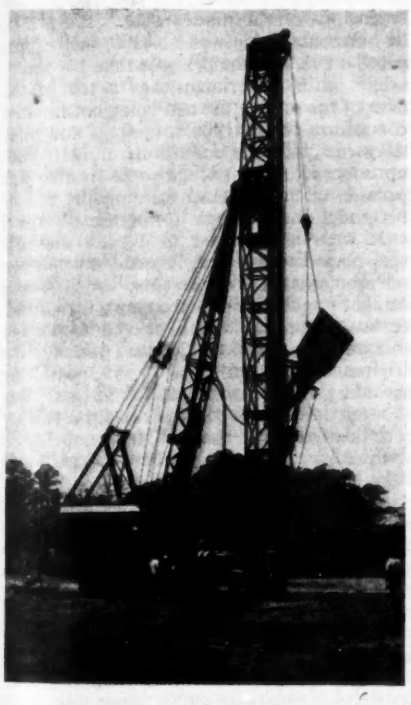
Bordentown—Trenton Interchange

After the completion of the sand drains, fill material was gradually deposited and compacted in thin layers on top of the sand fill blanket. Close control of the placing of this fill was exercised, and if high pore pressures or excessive sideways movement were observed the placing of fill was temporarily discontinued until sufficient consolidation had taken place. Fills were built up to the final profile grade, above which from 2ft to 8ft of overload fill was placed. In the vicinity of bridge abutments, where speed of consolidation was necessary, overloads of fill as high as 15ft were used. At some sites, fills as high as 60ft, including overload, were placed on top of the sand drains.

As the fill increased in height its weight

Turnpike Underpassing Pulaski "Skyway" and Crossing Passaic River

tended to compress the underlying material more and more, forcing the water from the mud into the sand drains, and then up into the sand blanket, whence it drained off into the adjacent meadows. After the fill reached the overload grade, in spite of the necessity of complying with the fast completion schedule for the turnpike, a period of several weeks was insisted on in order to obtain stabilisation of the underlying meadow



Sand Drain Driving Rig

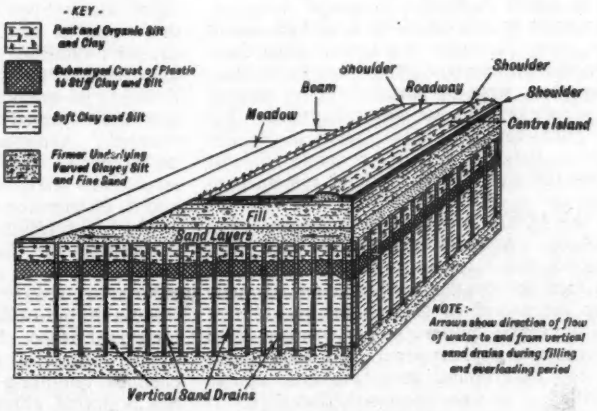
mud. Longer periods were provided where possible, and would generally have been advisable had time permitted, to accomplish a more complete stabilisation.

Once the settlement curves showed a definite tendency to flatten out it was known that stabilisation was nearing completion and that the date for the safe removal of the overload, to allow for the construction of bridge abutments and paving, could be set. Settlement and pore-pressure readings were taken twice weekly. After the stabilisation of the underlying strata and removal of the overload fill, the grade was ready for the commencement of pavement construction.

Hydraulic Fill Emplacement

An operation of particular interest was the placing of ocean sand as fill by the hydraulic method on the section of turnpike extending over almost 6 miles from Elizabeth to Newark. Over 5,000,000 cubic yards of this material were placed for the turnpike, 750,000 cubic yards being placed in the peak month. Two basic methods were used to handle the sand from the waterside booster station. The first consisted of loading hopper dredgers in lower New York Bay and discharging the loads, varying from 2000 to 3000 cubic yards per dredger for the three dredgers in use, at boat lines which were permanently set at dockside in the extreme westerly end of Port Newark basin. The dredger pumps moved the material through 20in diameter spiral-welded pipelines to a booster station, where motor-driven pumps propelled it up to 2½ miles further, at the rate of 1000 cubic yards per hour. The waterborne sand was deposited first on firm ground or on an area in which sand drains had been driven to stabilise the soft underlying material. After the first layer of sand was placed bulldozers built sand dykes to retain the rest of the fill. Wooden spillways were constructed to control the run-off water and carry it to the marsh. Succeeding layers, deposited to depths averaging 3ft to 4ft, eventually built the fill up to grade. Dredge water seeped out through the porous fill and excellent consolidation resulted.

The second method of supplying sand to the booster station consisted of loading bottom-dump barges by dipper dredger in the vicinity of Long Island. The barges were towed to the same location in the Port Newark basin and dumped their loads on the bottom. A hydraulic river dredger was then placed in operation in the basin to pick up the sand from the bottom as it was deposited and pump it to the booster station. Beyond that point the operation was the same as that previously described.



Sand Drain Method of Consolidation

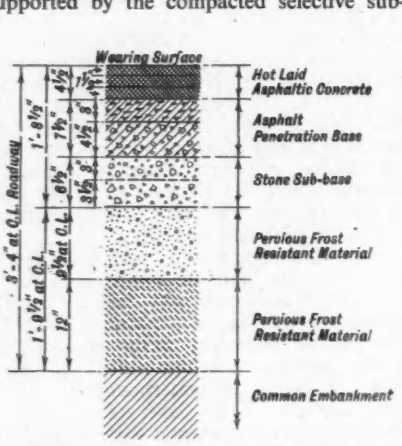
Pavement Design

The specification adopted for the turnpike road bed required the excavation of all materials to a depth of 36in below the finished pavement grade. From 36in to 24in below grade the backfill was to be a pervious frost-resistant material having not more than 10 per cent passing the 200 mesh sieve, having a plasticity index of not more than 6 and a California bearing ratio of not less than 15 per cent. From 24in to 8in below the finished grade the backfill was to be a pervious, frost-resistant material having not more than 6 per cent passing the 200 mesh sieve, a plasticity index of not more than 3, and a California bearing ratio of not less than 20 per cent. The finished grading section was 8in below grade at the centre line, with a 2 per cent cross slope for temporary drainage prior to paving. Material from 3ft to 4ft below the finished grade was required to be compacted to 90 per cent of the modified standard of the American Association of State Highway Officials; material above the 3ft level to 75 per cent of the modified standard. This requirement applied to both cuts and fills.

Once this specification had been established, designs were developed both for a "flexible" pavement and for a "rigid" pavement, based on an axle load of 36,000 lb. The flexible pavement design consisted of a 6in pervious non-frost-active sub-base; two 3in layers of waterbound macadam base course; a 2in layer of penetration macadam base course, and 4½in of asphaltic concrete surface course. The asphaltic concrete was to be laid in a 2½in binder course and a 2in surface course. Side shuttering was to be used to ensure a sharp edge on the pavement and a smooth riding surface. The 6in sub-base was specified to consist of well-graded crushed rock, slag, or gravel of a durable and frost-resistant character. It was felt that such a choice would encourage the use of local materials and would be economical. Grading requirements were specified to ensure a material which could be compacted and still be sufficiently porous to drain well. The 6in depth was to be placed in two layers to ensure maximum compaction. The base course, which was designed to consist of two 3in layers of waterbound macadam and a 2in layer of penetration macadam, is the equivalent of many secondary roads

throughout the East of the United States. Crushed stone or crushed gravel fully choked with screenings was specified for the waterbound base. For the 2in penetration course crushed stone was specified, using from 1·6 to 1·8 gallons of asphalt per square yard. Sufficient chips to fill the surface voids were to be added while the bituminous binder was still liquid. A rubber-tyred roller weighing 25,000 lb per wheel was specified for compacting the top course of the waterbound macadam, in addition to the conventional rolling of each individual layer. The asphaltic concrete was designed to consist of a 2½in levelling or binder course and a 2in surface course. These were to be plant mixed and hot laid. A tack coat was specified for the macadam base course to be applied before the levelling course was placed.

The rigid pavement design consisted of a 10in thick standard Portland cement concrete pavement on a 6in pervious sub-base, all supported by the compacted selective sub-



Section Through Centre Line of Roadway

grade previously described for the flexible pavement. The 6in pervious sub-base design was substantially the same as that specified for use under the flexible pavement.

In order to determine the lowest pavement cost, the Turnpike Authority decided to request alternate tenders. Accordingly, contract plans were prepared for both designs of pavement and were duly advertised. The bid prices totalled approximately 40,300,000 dollars for bituminous concrete against 45,400,000 dollars for Portland cement concrete, or a difference of 5,100,000 dollars for the 3,900,000 square yards of pavement involved. After all the tenders had been received, the Authority awarded the paving contracts for the flexible pavement. Shortly after the award of these contracts, one of the successful bidders made a proposal to substitute an asphalt penetration base course for the waterbound macadam base course specified. It was proposed that 7½in of penetration base be placed in two layers instead of the 8in of macadam base consisting of 6in of waterbound macadam and 2in of penetration macadam. The ½in differential in depth was to be made up by increasing the thickness of the sub-base from 6in to 6½in. Within a short time, the other successful bidders on the pavement contracts made similar requests to the Turnpike Authority and it was decided to use the asphalt penetration base throughout the turnpike. The accompanying diagram shows the pavement section at the centre line of the roadway in accordance with the specifications approved finally by the Turnpike Authority.

The pavement contractors made another request which the Turnpike Authority accepted. Side shuttering had originally been specified, but the contractors offered to place the 4½in depth of bituminous concrete in three courses instead of two courses as specified, if the side shuttering could be eliminated. The contractors agreed that the elimination of the shuttering would in no way alter the requirements of the specifications regarding the line, grade and riding qualities of the pavement.

(To be continued)

Applications of Scale Models in Engineering

By ROLT HAMMOND, A.C.G.I., A.M.I.C.E.

No. II—*(Concluded from page 184, August 8th)*

Amongst models discussed are one for the study of irrigation in Iraq, that of Malmo harbour used by Professor Hellstrom, a tidal model of the Thames Estuary for the study of siltation, that of the Mersey Estuary used by Professor Gibson, river models used by Sir Claude Inglis at the Poona Research Station, and models of a dog-legged staircase at the Festival Hall for the determination of stresses, and the Dome of Discovery for the study of wind loading.

Silting and Dredging

A VERY important matter which concerns dock and harbour engineers is the siltation which takes place in estuaries and rivers and which often involves the authorities in heavy expenditure on maintenance dredging. In 1949, at the request of the Port of London Authority, the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research began a survey of the River Thames from Teddington to the sea, a distance of about 60 miles, with the object of studying the causes and investigating the sources of silt in the river and of observing the velocities, direction and duration of the tidal currents on the ebb and flood at varying depths during neap and spring tides.

Simultaneously a scale model of the river, reproducing existing conditions and tidal variations, is being constructed by the Hydraulics Research Organisation of the D.S.I.R. under its Director, Sir Claude Inglis, M.I.C.E., one of the most eminent living authorities on this kind of work, in order to determine the measures required to overcome excessive siltation occurring in certain reaches and thereby to reduce the present heavy dredging programme now necessary to maintain the required depths in the navigable channels. Samples of the river water will be taken to determine by chemical and mechanical analysis the properties of the silt and its distribution in the river.

Much information will also be required concerning the fresh water, discharge of sewage and trade wastes into the river from tributaries, sewage outfalls, generating stations and industrial undertakings; a very important aspect of this work will be a study of the effect of these discharges on the chemical condition of the estuary water and the polluting effect of discharges of very large quantities of waste waters. The impurity of the Thames has been a matter of concern for many years and inquiries were held to determine causes in 1869, 1878 and 1882. It is expected that the present survey will take from two to three years to complete, by a staff including chemists and a hydrographer with headquarters at Tilbury, where the Port of London Authority has provided a laboratory and a 75ft launch.

A very outstanding example of the value of model experiments carried out on a sound practical basis is provided by the investigations of the training works and dredging to be undertaken in the Mersey. Since the various factors involved in the alignment and construction of training banks are very important and often very costly, the problem was studied with the aid of a scale model, based on the principles put forward by Professor Osborne Reynolds and presented at a meeting of the British Association in 1889. In 1923, when the first model investigations were being made, very few models had been constructed in this country for the study of any particular problem. All data available were therefore collected and a model was constructed covering the bay some distance beyond the bar lightship and extending to Warrington including the Cheshire shore to Hilbre Point and the Lancashire shore to Formby Point, the axis of the tidal generator being about at right angles to the axis of the Queens Channel. The rectangular dimensions of the model were 48ft by 28ft, the horizontal scale was 1 : 4200, the vertical scale 1 : 192, and the periodic time 147 sec.

The initial experiment was a test of the truth of the model, the bed being constructed to conform to the 1906 soundings and tides being run until the conditions of 1910 were reproduced. At this stage some trouble was experienced in the sand forming the bed of the model and in ripple formation. Vertical scale was then altered to 1 : 168 and the tidal period to 141 sec, in order to increase the momenta of the currents, which it was thought might eliminate the ripple formation. Vertical scale was again altered to 1 : 144 and periodic time to 128 sec; finally, the original vertical scale of 1 : 192 with the periodic time quickened to 95 sec was adopted and the model was run for a further period of 10,664 tides. This model was operated for 286,848 tides between 1923 and 1929.

Although the results obtained showed that valuable data could be derived from model experiments for making decisions on the location and size of training banks, it was considered that the model did not give sufficiently reliable information upon which such costly works could be based. A larger and more elaborate model was therefore constructed by Professor Gibson at Manchester University in 1929, where important scale model investigations had been completed in connection with the proposed Severn Barrage scheme; much valuable experience was gained from this work which greatly advanced the technique of model construction and operation, which was applied to a particular case when the model results could be compared with actual results in nature. Professor Gibson agreed to undertake this work and to collaborate with the engineer-in-chief of the Mersey Docks and Harbour Board and with other experts who were studying the various problems involved.

This model (Fig. 5) had a horizontal scale of 1 : 7040, a vertical scale of 1 : 190 and

vertical exaggeration of 37 : 1, a scale of horizontal velocities 2·68 : 1 and a tidal period of 87·1 sec. The model extended from Warrington up river and the Mersey and Dee estuaries were both included in the scope of the model, since it was considered that the Dee would have some effect on the velocities and direction of the tidal currents entering the Mersey. The shore line of the model extended from 2 miles west of Point of Ayr and seawards to about 4 miles north-west of Queens Channel, the axis of the tide generating box being slightly east of north. The surface area covered by the model was about 575 square miles, tides being produced by the vertical motion of a motor-driven balanced displacer of 21 square feet mean sectional area in plan, the stroke of which was varied from springs to neaps by epicyclic gearing. The main bed material of the model was sand having a mean diameter of 0·0071in or about 0·77 times that of the average sand in the bay and in the approach channels, and a satisfactory material for the model was obtained by using a fine silicious sand. (Fig. 6 shows a simple arrangement for varying tidal ratios.)

Many samples of sea water were taken from points in the estuary and bay, and were investigated for rate of coagulation and settlement of Mersey mud (as used in the model), and for the corresponding rates in alum solution, which indicated that the correct rate of settlement in the model was attained with an alum concentration of 0·01 per cent by weight. Suitable arrangements were provided so that further solution could be supplied at the seaward end of the model to compensate for the influx of river water at the Dee and Mersey, and for efflux over the spillway in the tide box. Provision was also made for introducing upland waters corresponding to the up-river flow of the Mersey and Dee. Silt was supplied in suspension in the river feed water corresponding to a mean value of about 1 : 11,400 by weight, which was actually observed in the river.

The tidal mechanism gave tidal range normally varying from 31ft at springs to 15ft at neaps, and experiments were made, stroke and shape of tidal plunger being modified until a very close agreement was obtained between natural tide curves and those of the model. Suitable tidal conditions having been obtained on the model, directions and velocities of the current had then to be adjusted in relation to those actually observed in the bay and in the estuary. This involved many experiments and the introduction of both solid and perforated baffle plates between the tide box and the model, until finally the velocities in the model differed from those in nature by only 0·2 knot. The effect of prevailing winds was produced by electric fans, which, in full operation, provided surface waves equal to a height of 3ft on the model, prevailing wind directions being west and west-south-west ; storm conditions could be imitated by a rocker paddle operated by hand for model periods of two or three days.

A convincing experiment was carried out in order to check whether the model was capable of producing changes in its bed comparable with those which actually took place in the estuary, after satisfactory adjustment of tides, velocities and currents had been attained. The bed of the model was moulded to the contours existing in 1900 before erosion took place at Taylor's Bank and the extension of the Askew Spit, which took place during the following years. The model was then operated for a period equal to 4·25 years in nature, when results showed very marked erosion of Taylor's Bank and corresponding accretion of Askew Spit having the same general nature as had actually occurred in the estuary. Vertical exaggeration of scale in this model was much greater than in the first experimental model made, and the tidal period was very much less. The accompanying sketch shows the general layout of the model and is based on information given in the James Forrest Lecture for 1947, delivered to the Institution of Civil Engineers by Professor Jack Allen, D.Sc., M.I.C.E.

From 1930 to 1932 the model was operated at Manchester University on various schemes

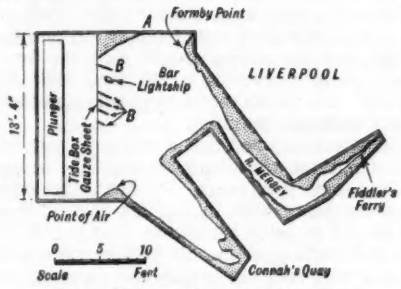


Fig. 5—Outline of River Mersey Model

for 178,816 tides, when it was transferred and operated at Liverpool because the space was required for other model experiments at Manchester ; thirteen experiments were run at Liverpool and the model operated for 217,430 tides. The various problems were considered and the final works and proposals were tested by the model, which indicated that the works would have the results expected, and therefore the Mersey Docks and Harbour Board obtained approval of the Mersey Conservancy and of other interested bodies, and the works were duly authorised.

Many people, specialists and laymen alike, have wondered how it is possible to obtain accurate and reliable results with models having distorted scales, and this important matter has recently been reviewed in an excellent fashion by Mr. T. Blench, B.Sc., M.I.C.E., in an article (" Scales for Moving-Bed River Models," by T. Blench, B.Sc., M.I.C.E., *The Dock and Harbour Authority*, March, 1951). He rightly points out that a model is like a work of art ; it is not a slavish copy of something, but a representation

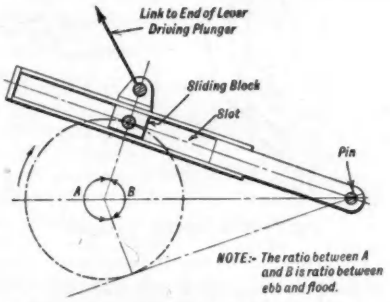


Fig. 6—Arrangement for varying Tide Ratios

which has to be interpreted. This obviously demands expert practical knowledge of the basic principles of behaviour likely to occur in the prototype, and which will provide laws of correspondence.

Control of Rivers and Canals

The remarkable results achieved by Sir Claude Inglis at the Government of India Research Station at Poona are extremely valuable in demonstrating the practical application of model techniques (" The Behaviour and Control of Rivers and Canals, with the Aid of Models," Yeravda Prison Press, Poona, 1949). It was not until 1934 that work began to be received at the Station from the railways, and Sir Claude gives some extremely interesting facts about this notable work. He was first called in by the Hardinge Bridge Committee, which had been appointed by the Railway Board to advise in connection with damage caused by erosion upstream of the Hardinge Bridge. This bridge, spanning the Ganges at Paksey, on the Assam-Bengal Railway—then known as the Eastern Bengal Railway—was considered to be endangered by possible outflanking, and nearly a million pounds had been spent during the previous two years in an attempt to prevent further damage. After inspection, and after detailed model experiments had been carried out, recommendations were made which were generally acceptable to the committee. A pilot model was first constructed to give a maximum discharge of 1 cubic foot a second and this was followed by a large model. The pilot model did not give similar results to those obtained in the larger model, nor did the larger model produce the same results over a period of years, as occurred later in the Ganges, because it was found that erosion took place much more rapidly than in the river, whereas silting took place much more slowly. Sir Claude was able to forecast, however, with a high degree of accuracy, what would happen in the river from year to year, and he predicted with an error of only one season, the year by which flow would change from the right bank to mid-stream before moving to the left bank. This was after he had undertaken an extended analysis of what had previously occurred in the river, combined with information derived from model experiments. The important point to bear in mind is that the relative merits of alternative treatments were clearly demonstrated by the model experiments.

Another very instructive work carried out under Sir Claude's direction concerned the model investigations and surveys connected with the flow of the Gandak River at Bagaha. When the river was flowing normally through the bridge in 1922 there were still vestiges of earlier river channels visible. Since 1860, however, the river remained within a belt some 2 to 5 miles wide ; since the railway was constructed the river swing has not exceeded some 3 miles. A comparison of the conditions in 1886–96, before the bridge was built, and conditions in 1921–22, ten years after it had been constructed, showed that in that period of twenty-five years little change had taken place, the river continuing to flow along the hard left bank, upstream of the position selected for the bridge. By 1922, the river had bifurcated into two channels, 4 miles upstream of the bridge, joining again about 1½ miles above the bridge to flow axially through it ; the sketch (Fig. 7) shows river conditions in 1922 and 1925 for comparison. By 1924, the river upstream of the bridge had begun to embay behind the right embankment, and the water, after concentrating at the nose of the right guide bank, flowed across to the left bank as a concentrated stream, flowing at high velocity and with sharp curvature through the three left spans of the bridge. The result was that pier No. 14 failed, and the right guide bank also failed.

After the flood of 1924, the Chhitauni groyne was constructed, the idea being to deflect water back through the bridge. In practice, however, the effect of this groyne was to pull the river still more strongly around its nose, thus acting as an " attracting spur " ; as a result, the river cut through the south-west approach embankment to the bridge. As the river was still pressing towards the western approach embankment in 1925, flooding the country upstream of the bridge, planned repairs were abandoned

and the breach was accepted. In 1934, the pitching material of the Chhitauni groyne was removed above water level and the groyne was abandoned.

In 1938, the river was still unfavourable for diverting it back through the bridge, because a considerable proportion of the flow was along the nose of the Chhitauni groyne, which was still holding the river. In January, 1940, however, flow along the right bank increased, and a large part of the river was flowing along the outside of the right guide bank, a condition favourable for diverting the flow back through the bridge. After the 1940 flood season, conditions had again become less favourable; by December, 1942, the main flow of the river was again along the right bank near Chhitauni, and in December, 1943, the whole river was at its most extreme westerly position, near Chhitauni Ghat Station. At this stage a scale model was constructed to study the problem of how the river could be deflected back through the bridge.

The bed of this river consists of medium sand having a mean diameter of 0·38mm, with no underlying stratum of hard material. The maximum flood discharge in 1924 was estimated by the railway staff to be 294,000 cusecs, based on a fall of 1·25ft per mile on a measured straight stretch downstream of the bridge, using the Mississippi formula :

$$V=[(225R \cdot S^{\frac{1}{2}})^{\frac{1}{2}}-0\cdot0388]^2.$$

It was decided that to reproduce possible alternative river positions in the model, an entry length of about 4 miles should be provided in addition to the model length—that is, equivalent to 10 miles upstream of the bridge to 3 miles downstream. The material selected as most suitable for this experiment was Theur sand, passed through 30-mesh sieves, giving a diameter of 0·20mm, which would become coarser in the model, because part of the finer material would be washed away. The longitudinal scale was 1 : 200, giving a maximum discharge, based on meander length, of 7·5 cusecs, equivalent to an actual discharge in nature of 300,000 cusecs.

The programme of experiments was based on the conditions obtaining in the cold weather of 1942–43, and a groyne was planned to run out from the high ground along the left bank which would extend about 1500ft into the then existing main channel. The object of this groyne was to attract flow towards the left bank, and so open up the existing channel over a certain section. Experience showed that as soon as the water reached the high ground on the left bank, this channel would be permanently held and would develop, while the main stream, which, in 1943, flowed across to the Chhitauni groyne, would at the same time deteriorate and would cause further enlargement of the left bank canal; eventually the main river would flow through the bridge, as before 1924.

Unfortunately, during the flood season of 1943, a cut-off "chord" channel developed as shown in Fig. 8; this developed rapidly and the left bank "arc" channel deteriorated. By the end of the flood season, the cut-off channel had become the main channel. The main current then took an abrupt turn at section *A–A*, bifurcated 1 mile downstream of this section, and then passed through the cut-off chord channel; by November, 1944, it appeared to be taking about 80 per cent of the total discharge. The velocity of the stream was then 4ft per second and the depth of water was 22ft on the outside of the curve, and 8ft on the inside of the curve. Thus, the "arc" channel which was the main channel of 1943 had, by 1944, become a subsidiary channel carrying only about 20 per cent of the discharge. This meant that the scheme contemplated in 1942 was no longer feasible, and that the river would desert the left bank between cross sections *B–B* and *C–C*; in other words, the axis of the stream had permanently changed.

Model experiments were therefore carried out to try and discover if the model could provide the answer as to what changes were likely to take place in the future course of the river. These experiments showed that the "chord" channel would develop further and that it would take nearly the whole flow. However, further changes would result as much from accretion as from scour, and the time scale for silting is quite different from, and much slower than, the time scale for scour; the model therefore failed to give any indication on this point.

It was concluded that it might be possible to divert the river back through the bridge after some ten years, but that the odds against being able to do this was at least 3 to 1. It was also shown that the depth of foundations of the old bridge was inadequate and that in future the foundations would be liable to give trouble. Further investigation into the whole problem revealed that there was an admirable site for a new bridge 68 miles downstream, where the river flows between hard and well-defined banks, and which had not at that time been appreciably eroded within living memory. The hydraulic gradient flattens just below this

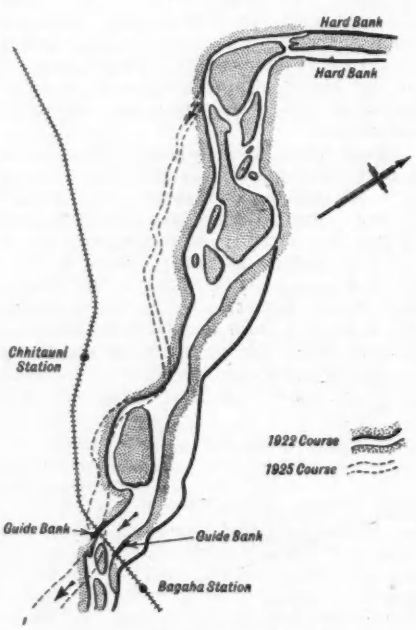


Fig. 7—River Gandak at Bagaha

site, and the highest flood recorded (1903) gave a gentle fall of only 9in per mile. Two borings taken at this site showed sand to a depth of from 30ft to 50ft below cold weather water level with underlying stiff clay to a depth of 100ft, the latter being the limit of depth to which borings were carried.

Sir Claude Inglis quoted this example at length to show what nonsense it is to expect that a model will reveal the answer to a problem of this kind. Yet he emphasises that if such a model is used in combination with experience and analysis of past behaviour, it can give just the information required. In this case, the combined investigations proved that it was unlikely that the old bridge could be brought into use again, and that it would always be liable to give trouble. Finally, it was proved that it would be wise to abandon the damaged bridge and to build a new one at a very suitable site 68 miles downstream.

The success of the Hardinge Bridge experiments gave prominence to the work of the research station at Poona and it conducted several tidal investigations, one of which concerned the Hooghly above Calcutta. At the beginning, this model was more than 1000ft long, tidal flow only being generated at the downstream end, but it was found that better results could be obtained by shortening the model to 500ft, producing the ebb flow at the upper end. The main object of this long model, with a natural vertical exaggeration of 5, was to reproduce lines of flow and tidal conditions, to visualise the general problem and to elucidate the flow conditions required in a short, large-scale model with only a slight reduction in width. Tides had to be generated at both ends, and the slope exaggeration produced in this way was much greater relatively than the vertical exaggeration in terms of width.

Sir Claude has been careful to point out in his report that although advice has been given in many cases without the use of models, this has seldom been because models were considered unnecessary, but rather because there was insufficient time or facilities available. In such cases, advice has been based on field experience combined with the results of earlier model investigations. Similarly, when advice was given without inspection, this was not because inspection was considered to be superfluous, but because time could not be spared; it is Sir Claude's firm opinion that in all but very simple cases river problems should be investigated on the spot, both by personal inspection and by discussion on site with those familiar with the district; this alone makes it possible to arrive at a reasonable diagnosis of the case.

He states that it is unlikely that any important work—whether concerned with new structures or with the remodelling of existing ones—will be carried out in future in India without model experiments. Yet he makes a special point that the limitations of models should always be kept in mind, and in the case of mobile models, success will depend mainly on the ability of the person directing the experiments to visualise and to diagnose the conditions which have led up to the present position and, in the light of that knowledge, to predict changes which will take place in the years to come. A model cannot possibly give reliable information unless the conditions imposed are correct.

After many years' experience of this important subject, Sir Claude admits that he has found it most difficult to decide what has helped him most to understand conditions and to diagnose causes; comparisons of model studies with field results are a very valuable aid, in that models have enabled him to understand what is happening in a river in far greater detail than is possible from mere inspection. Field inspection has shown him where the model fails to reproduce river conditions, and how far inherent differences must be taken into account. Reproducing in a model what has occurred in a river does not prove that the experimenter can predict future behaviour, as is generally assumed.

He gives a striking example of this fact. On one occasion, before going on tour, he had explained to a new assistant why it was impossible to reproduce in a model of the Jumna River certain changes which had taken place during the preceding flood season. On return from tour, the assistant told him he had had no difficulty in obtaining the correct result. What he had actually

done, however, was to develop a main channel which was roughly in the same position as the main channel in the river at the end of the flood season; but whereas the model channel had altered its course only once, the river had changed course four times during the flood season, leaving vestiges of three channels, one of which would reopen the following year—as the main channel—and the distribution of coarse and fine bed material was consequently highly complex in the river instead of simple, as in the model.

True scales for accretion and scour being different in river models, they can only give closely correct results during periods of scour, and where portions of the model are rigid, the rigid parts of the model have to be distorted to give even approximate results. River models cannot, therefore, be used to predict changes over long periods; but they are most valuable—providing these

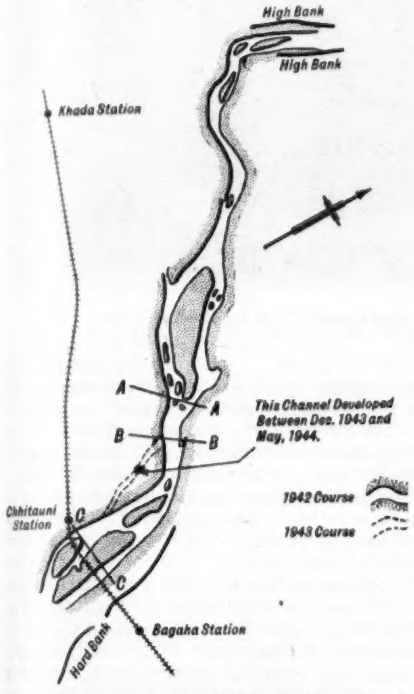


Fig. 8—Development of Chord Channel

inherent limitations are borne in mind—in helping those investigating river problems to understand conditions and thus to predict future changes in the light of this knowledge.

Scale models are extremely useful for helping to solve complex structural problems, an interesting recent case of this being the design of the dog-legged staircases at the Festival Hall, South Bank, London ("The Design and Construction of the Royal Festival Hall, South Bank," by E. O. Measor, B.Sc. (Eng.), M.I.C.E., and D. H. New, B.Sc. (Eng.), A.M.I.C.E., paper No. 5816, Institution of Civil Engineers, 1951). The problem is basically similar to that of a spiral staircase, inasmuch as there is a single continuous structural member with its ends supported at points which are not vertically above each other. Also, the resultant load line does not coincide with the centre line of the structural member. This end support gave the staircase greater fixity than was the case with the spiral staircase, and it was important to analyse it with the ends fully fixed. However, since one flight was longer than the other, the staircase was not symmetrical and it would have been extremely laborious to solve it analytically. Consequently, a mathematical solution was obtained for an "ideal" staircase with both flights equal; this problem was solved by strain energy in the same way as that of the spiral staircase.

A scale model of the actual staircase was made and investigated by the method of Pippard and Sparkes as set forth in the *Journal of the Institution of Civil Engineers* for November, 1936, to determine the effect of modifying the dimensions to produce an "ideal" staircase amenable to calculation, and to see whether asymetrical loading produced stresses greater than those caused by uniform loading. It was found from these experiments that the greatest error caused by the modification of the dimensions was 20 per cent, whilst asymetrical loading never produced greater stress resultants than full symmetrical loading.

The completed staircase was subjected to a test loading of 25 per cent in excess of the designed live load. Maximum vertical deflections observed were 0·30in at the extremity of the cantilever landing, which increased to 0·37in after the load had been left in position for seven days. On removal of the load, there was a residual deflection of 0·07in; there was movement of the landing of 0·10in towards the upper lateral flight. This model experiment is an ideal example of scale model work carried out with common sense and ability, whereby it has been possible to avoid long and costly calculation and to rely instead upon trial and measurement.

Another recent example of scale model research for the solution of a structural problem has been provided by the work carried out on the design of the Dome of Discovery for the Festival of Britain, 1951 ("The Structural Design of the Dome of Discovery, Festival of Britain, 1951," by Gilbert Roberts, B.Sc. (Eng.), M.I.C.E., Structural Paper No. 28, Institution of Civil Engineers, April 3, 1951). The effect of wind on a large structure of this shape could not be predicted and it was therefore decided to make a detailed experimental investigation on a model of the Dome. Extensive tests were carried out by Professor N. A. V. Piercey, D.Sc., M.I.C.E., in a wind tunnel at Queen Mary College. A 2ft diameter model was provided with a row of pressure holes along a diameter, and was so constructed that the spherical dome could be rotated relative to the lower part. Pressure holes were also provided on the apron sheeting and on the drum wall. This model was used to investigate pressure distribution due to winds from various directions and inclined to the horizon at angles up to plus or minus 11¼ deg.

The model showed that suction is present over most of the dome roof, the maximum value being about 10 lb per square foot in a 75 m.p.h. wind, which is the maximum velocity likely to occur on this site at roof level. On the apron, however, suctions or downward forces up to 16 lb per square foot occur over small areas. The model was also used to find the effect of surrounding buildings. In general, when the Dome was in the wake of some obstruction, it was subject to a wind which was deflected downwards, but whose speed was slightly reduced. The worst effect occurred with a wind blowing from the direction of County Hall, which deflected a steady level wind of 75 m.p.h. downwards by about 11 deg., the reduction in speed being about 7 per cent.

This example is particularly appropriate as a contemporary tailpiece to this article, because the Dome of Discovery will rank as one of the outstanding structural achievements of this modern age. It was the largest of the temporary buildings on the South Bank site and the largest aluminium alloy structure ever built, and an adventurous excursion into entirely new fields of structural engineering and design.

High Frequency Heating

By A. E. WILLIAMS, Ph.D., F.C.S.

The use of high-frequency heating methods in industry is rapidly expanding. Here the use of the method is surveyed in its applications to the heating and melting of metals, the hardening of steel, soldering, gluing, drying, and in the plastics industry.

ALTHOUGH the use of high-frequency heating in industry is still far from attaining saturation point, the use of this medium is growing steadily. As is well known, there are two distinct kinds of high-frequency heating: dielectric heating, which is applied to materials having only poor electrical conductivity, and induction heating, which is applied to conductors such as metals. Induction heating is by no means new, for it has been widely applied in the industrial furnace for some years, but not through the medium of valve generators. Broadly speaking, there are three methods of creating high-frequency current. For frequencies up to about 15,000 c/s a motor generator may be used, while a spark generator will produce about 300,000 c/s. Compared with these units, however, the electronic valve generator is a much more versatile instrument where only moderate powers are required, for it can operate at frequencies up to many millions of cycles per second. In spite of this, the rotary machines are still the most economical for high-frequency heating in the larger eddy current applications. Recent developments have been largely concerned with the valve-operated generator and it has been adapted to operate in conjunction with many different types of work.

Heating of Metals

For the heat-treatment of small metal objects use is commonly made of a coil, connected to the output terminals of the generator and enclosing—but not touching—the work to be heated. High-frequency current flows in the coil and produces an alternating magnetic field, which induces circulating currents in the surface of the work within the field. In overcoming the electrical resistance of the metal considerable heat is developed, and since heat is produced only in the area of the work near the coil, by using coils of specific shapes local heating may be accomplished. The amount of heat generated is governed by the strength of the field surrounding the work and increases as the distance between the work and coil is diminished. In many cases the coil is of tubular copper and may be water cooled. For the heating of small cylindrical metal objects a simple coil following the contour of the work is all that is necessary, but where the work is of an irregular or an intricate contour the coil—to be effective and ensure rapid heating—must

be shaped approximately to simulate the contour of the work. At the high frequencies used the bulk of the heat is concentrated in the skin of the work and the heating of the interior of the object may be mainly by thermal conduction. The process is therefore very suitable for the surface hardening of steel and similar operations in which heat needs to be concentrated at the surface.

For a given work specimen, the factors which govern the depth of the heated layer are the frequency, power and time.

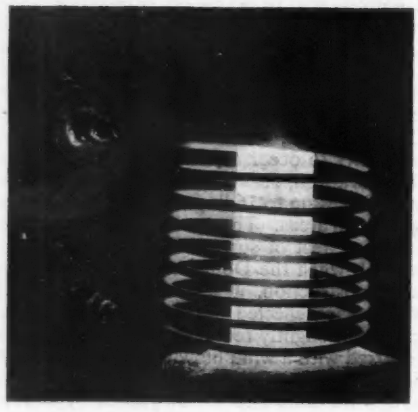


Fig. 1—Graphite Crucible Heated by Eddy Currents

The higher the frequency the smaller becomes the heat penetration, but the greater the power concentration the higher the surface temperature obtained and this increases depth of penetration by rapid thermal conduction. Similarly, depth of heat penetration is increased by lengthening the time of heat application. Under a specific set of conditions the rate at which metals will heat is governed by their resistivity and ferromagnetic characteristics; thus, copper—being a good conductor—heats less quickly than steel. With a particular kind of work the rate of heating that can be attained depends on the class of metal, its distance from the coil, and the precautions which are taken to prevent heat losses to the surroundings. Where the work has to be uniformly heated throughout, additional time is taken in allowing the heat to penetrate from where it is generated in the skin to the interior of the work. As an approximate guide for some classes of work it may be said that for temperatures up to 600 deg. Cent. or higher, if steps are taken to prevent heat radiation, a generator with a 5kW output will heat 3 lb of non-magnetic metal, or 8 lb of magnetic metal, through a temperature rise of 100 deg. Cent. per minute. The same generator would heat 2 lb of steel from 50 deg. Cent. to 550 deg. Cent. in approximately 1¼ minutes. A generator with five times the capacity of the foregoing unit would do the job in about 12 seconds, providing that the rate of heat penetration was sufficiently rapid to create a uniform temperature in the work within that time.

Melting Metals

In the treatment of precious metals, assaying, &c., it is frequently required to melt small quantities of material and for this purpose high-frequency heating has an advantage on account of its ease of control and inherent cleanliness. Metals such as tungsten and molybdenum can readily be melted by this process, and by the use of a conducting graphite crucible small amounts of non-metals may be melted. An example of the crucible method of heating is seen in Fig. 1 (G.E.C.) wherein a graphite crucible is brought to white heat by eddy currents induced in it by the high-frequency current flowing in the coil. With this method small quantities of non-metallic bodies can be melted in the crucible and in all such instances the heat is generated in the crucible itself and not in the charge.

Metals can also be melted on an industrial scale by using larger types of furnaces, as depicted in Fig. 2, which shows a melting furnace for the manufacture of special alloys at Phillips Blackburn Works Ltd. It is capable of dealing with 200 lb of metal at once and the high-frequency generator employed requires 400kVA from 400V, three-phase mains. In the generator the rectifier equipment is of the polyphase voltage doubling type, employing grid-controlled hot cathode mercury vapour rectifiers, delivering 18A at 20,000V. The output of the unit is smoothly controllable from zero to full voltage.

The valve-operated generator in metal melting is applied frequently in special cases, such as the preparation of alloys in controlled atmospheres, or to the melting of rare metals which need high temperatures, such as platinum, iridium, &c. In many other cases the ordinary induction heating furnace is very efficient and the valve-operated generator is not used.

Hardening of Steel

For the surface hardening of steel the high-frequency method is of great advantage due to the skin effect produced, because the heat is concentrated on the surface exactly where it is needed. On account of the high speed with which the process can be carried out, scaling can be eliminated. It will be obvious also that using a suitably shaped heating coil selected zones of the work may be treated, so that the usual procedure of "blanking off" those parts not to be heated is unnecessary. The depth of hardened skin produced is controlled by accurate adjustment of the speed of heating. Using a 25kW output generator, which deals with an area of work up to 12 square inches, hardening may be carried out to a depth of 50 mils in about 20 seconds. For depths up to 15 mils a heating period of around 2 seconds only is required, and to attain this high rate of heating a generator of larger power is required to cover the same area. By surface hardening steel in this way the interior metal is not raised appreciably in temperature, so that distortion of the work is very little, and after treatment, such as lapping or grinding, is often not necessary. In addition, surface hardening of shafts, &c., by this technique is quite feasible, as is also the interior surface hardening of cylinders, &c., by placing inside the latter suitable coaxial coils.

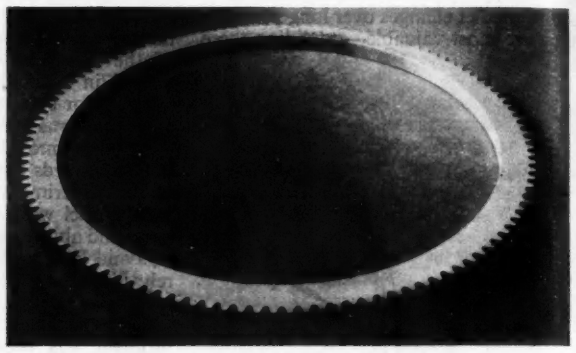


Fig. 3—Hardened Ring Etched to Show the Hardness Pattern

The teeth of gear wheels, ring gears, &c., may be hardened by placing the work inside a cylindrical coil. With such work the application of power from 1kW upwards per square centimetre of surface area is common practice. For example, 5cm diameter fine-toothed gears may be hardened to an average depth of 0·08cm in 2½ seconds, 3·5cm diameter coarse-toothed gears may be hardened to a depth of 0·04cm at the roots and 0·10cm at the tips in 6 seconds. In Fig. 3 (Redifon Ltd.) is seen a hardened ring etched to show the hardness pattern extending just below the roots of the teeth. Light has been concentrated on the lower left section in an attempt to show the pattern clearly.

Part of an automatic plant for the hardening of starter ring gears at the works of the Ford Motor Company, Ltd., is seen in Fig. 4, (Redifon Ltd.) showing the section in which the actual hardening process takes place.

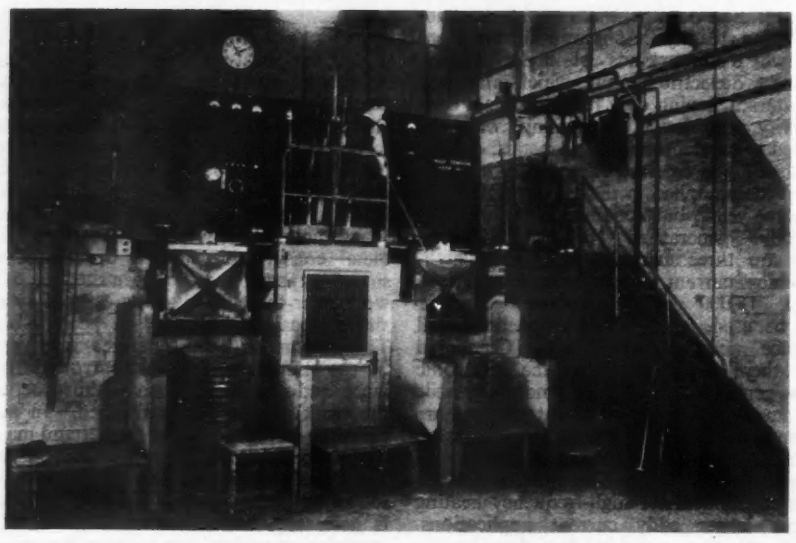


Fig. 2—High-Frequency Melting Furnace

Three sizes of ring may be handled, each having a heating coil of appropriate dimensions, the largest being at the bottom and the smallest at the top. The largest size of ring is 16·2in diameter by ½in thick, and this is hardened to a depth of 0·1in below the roots of the teeth; while the smallest ring is 10·2in diameter by $\frac{5}{16}$in thick and is hardened to a similar proportionate depth. These rings are made from 0·4 per cent carbon steel. The output of the hardening unit per

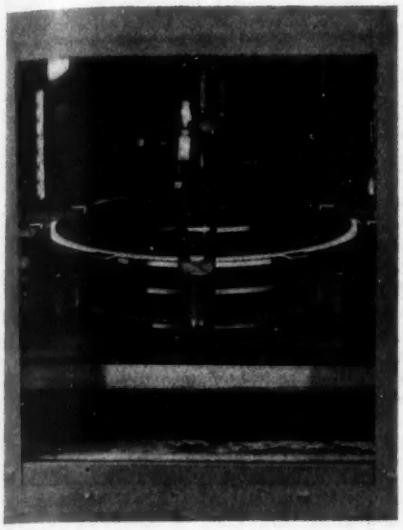


Fig. 4—High-Frequency Heating Coils for Ring Gears

twenty-four hours is 290 large rings, 320 medium and 1200 small rings. Handling of the rings within the unit is entirely automatic and the hardening equipment forms part of other automatic units which are housed together in a cabinet occupying a floor space of 8ft by 18ft. In this space is enclosed a high-frequency generator with an output capacity up to 30kW, a loading station into which the unhardened rings are placed, mechanism for transporting the rings to the heating coils, a quenching tank below the heating coils, and a cross-slatted wire mesh conveyor which

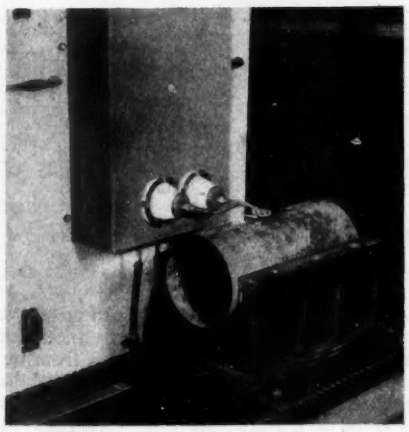


Fig. 5—Soldering with High-Frequency Current

carries the quenched work from the tank to a container outside the unit. The water supply to the equipment—used in the heating coils, quench tank, &c.—does not need frequent replenishing from the water main, for by a system of heat exchangers the same water is used repeatedly.

As distinct from surface hardening, through hardening generally requires lower input power densities, the time taken in through hardening varying with the size of the component. Through hardening with high-frequency generators of the valve type is normally confined to relatively small parts, bigger work being more economically done with other types of generator. As examples of work which is being done on a large scale by valve-operated generators it may be said that drills and taps from 1·0cm to 1·5cm diameter can be hardened within 10 seconds, both in normal high-carbon and high-speed steels. Knife blades may be hardened within 5 to 15 seconds, depending on their size. For the hardening of very small steel parts, such as the ends of clock and instrument spindles, &c., frequencies up to 50,000,000 c/s are used. With these high frequencies very small heating coils can be used efficiently, and by incorporating natural air blast or liquid quench it is possible to obtain very localised heating.

High-frequency heating is also economical for the annealing and tempering of small parts, and as is the case with surface hardening, it lends itself readily to repetition work on a conveyor or rotary table. Besides the treatment of small objects in such a manner, this form of heating is applicable to the continuous treatment of non-ferrous tube, bar or section, as it emerges from an extruder; while the annealing of both ferrous and non-ferrous rolled strip is also carried out. It is now extensively used for the annealing of wire between drawing processes.

Soldering

The operations of soldering and brazing may be conveniently carried out with the aid of high-frequency heating, for in most instances only local heating is required and the amount of metal to be heated is comparatively small. Power used in such processes is low; for example, a generator with a 5kW output will raise nearly 8 oz of copper to soft-soldering temperature in about 15 seconds, and a 100W unit will similarly handle 3 grammes of copper in the same time. Typical applications are the brazing of tips to tools, assembly of domestic ware, brazing of cycle frames, the fixing of studs and handles to a variety of equipment, and the seaming of tin cans. Generally the process consists of assembling the parts to be joined in a jig or supporting frame, together with a strip or plate of the required jointing material with flux, then exposing the work to the heat from suitably shaped coils. An average soldering or brazing job is complete within a few seconds by this method. An example of soldering is illustrated in Fig. 5, (G.E.C.) wherein a longitudinal joint in a tinplate cylinder is passed under a heater coil. A strip of solder placed in the joint is melted and the joint is completed in about 8 seconds. With many kinds of work it is possible to incorporate this method of soldering and brazing in production lines.

Dielectric Heating

The dielectric method of high-frequency heating is applied to the treatment of materials which are normally non-conductors of electricity. In these cases heat is not concentrated in the surface of the work, but is commonly uniformly distributed throughout the latter. When a condenser is formed by placing, for example, a copper plate on either side of a block of wood and a suitable current is passed through the plates, the wood absorbs power uniformly throughout its mass and heat is created within the wood. The same occurs with plastics and other non-conducting substances. Using a specific voltage and frequency on work of standard

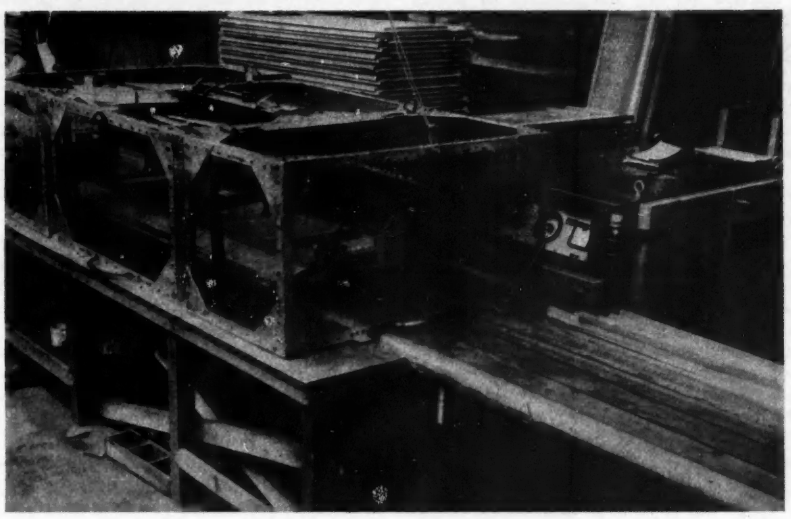


Fig. 6—Glue Setting on Wardrobe Production

size, the amount of heat created is governed by the power factor and dielectric constant of the work. The creation of a uniform heat within the work depends on the latter being of an entirely homogeneous character; for example, a block of wood not of uniform moisture content would not be evenly heated throughout. Compared with other methods of heating materials which are poor conductors of heat, the advantage of high-frequency heating is that the heat pervades the material uniformly throughout its mass. When other forms of heating are used to attain any elevated temperature in the centre of the material, it involves either heating the surface higher than is necessary, thus possibly damaging it, or subjecting the material to a prolonged heating period, which is time-consuming. It is due mainly to this big advantage of high-frequency heating in comparison with other known methods that it has become quickly established in industry as a practical process. To the manufacturer high-frequency heating means bigger outputs in less time.

Gluing

In the production of radio cabinets and similar work the advantage of high-frequency heating is based on rapid glue setting of assemblies in jigs. This form of heating is

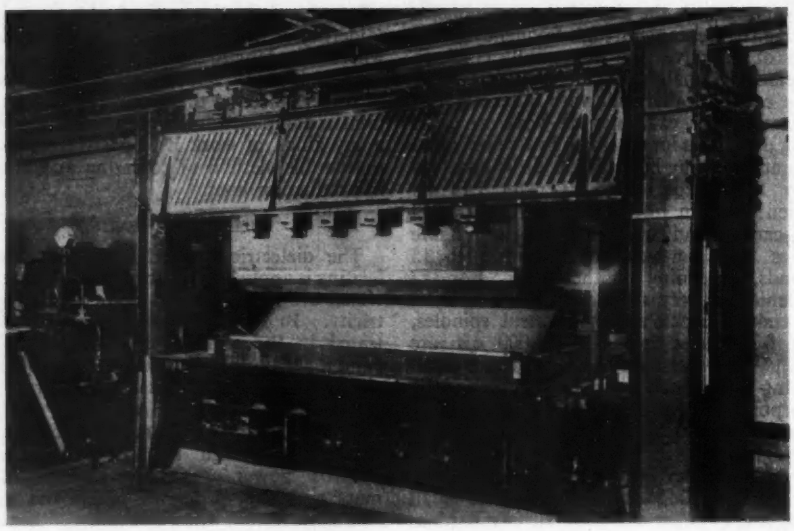


Fig. 7—Gluing of Laminated Timber Aircraft Frames

also applied to the manufacture of tennis rackets, aircraft parts, laminated ribs and stringers for boats, &c. It may be used in the local heating of veneered ply for bending, wherein the heat vaporises the moisture in the wood itself, so dispensing with the need for steaming, and as a result the bend sets in the jig within a few moments. Plywood may also be produced by this method of heating where electricity is cheap and big outputs are required, but the economics of this have not yet become firmly established, and a big proportion of plywood is still manufactured with the aid of a normally heated platen press.

In gluing two pieces of wood together, a metal electrode or plate is placed at either side of the joint to be formed, and it is possible to create heat in the glue very rapidly, even when the glue is absorbed in the wood. Since a big proportion of the heat is initially concentrated in the glue and in the surface of the wood, it is possible to complete an average gluing operation in a few seconds. When the current is switched off, the glue cools rapidly and the jigs may be used without delay for the next piece of work. In Fig. 6 (Redifon Ltd) h.f. heating is being used for glue setting on wardrobe production. While one loaded jig is in the cage another is being set up ready to take the place of the first as soon as the heating cycle is completed. In practice it is found to be not of great importance whether the electrodes are located parallel to the glue line or at right angles, the latter position being preferable where the contour of the work permits.

For the manufacture of special forms of plywood and laminated wood and the fixing of veneers, use is made of presses which are shaped to the contour required in the work. Where the dies are of wood the heating plates may be located in direct contact with the faces of the press, but when metal dies are used a layer of electrical insulating material is inserted between the dies and heating plates. In some instances where metal platens are in use it is possible to handle two assemblies simultaneously, the live heating plate being positioned between the two items of work, while the other electrode is formed by the platens themselves.

High-frequency heating has been successfully applied to accelerate the gluing of laminated timber aircraft frames, as in Fig. 7, (G.E.C.) which depicts a press for manufacturing spars for a well-known fighter aeroplane. The timber platens are metal coated to form the electrodes, and the assembly is heated under pressure by high-frequency current from the generator at the rear of the press. Another example of gluing is the production of cork blocks, in which a mixture of cork granules and glue is subjected to high-frequency heat, and pressure, in large moulds. By this method it is possible to make cork blocks of 6in thickness in much less time than is taken by the older convection oven method.

Plastics

In the plastics industry high-frequency heating is applied in several different ways. One of these is in the preheating of thermo-setting moulding powders before they are pressed. This makes possible the production of some thick-walled mouldings which could not be produced without such a method of preheating. Because the material going into the press is uniformly heated throughout, there is considerable reduction in the wear of the moulds, and a lower pressure may be used, while the breakage of pins and inserts in the moulding is negligible.

For the production of a great variety of goods in thermoplastic materials high-frequency heating is used to weld the edges of the material together. Two electrodes of the required shape are employed to grip the overlapped edges and the latter are heated and pressed together simultaneously. In Fig. 8 we show an example of a unit made by Redifon Ltd. for welding plastic sheet up to a size of 14in by 18in in a single operation, the operator merely sliding trays of work in and out of the machine. The electrode system consists of a moving top platen, mounted on insulators, which applies pressure and carries high-frequency current to the welding electrode. The lower electrode is earthed and comprises a tray with two welding stations on which locating frames are fitted. This tray slides on top of the self-aligning lower electrode, thus producing good electrical contact and uniform pressure on the parts to be welded. When a loaded tray is in position under the press a circuit is automatically energised and this closes the press and switches on the current. A process timer cuts off the current when the welding time is complete, the top platen is raised and the machine is ready for the next cycle. Such a unit rapidly produces toys, bags, gloves, wallets, &c., from shapes cut from plastic sheet.

In the manufacture of thick insulating boards high-frequency heating is used for pre-heating stacks of impregnated, resin-bonded, paper and cloth sheet, pressure then being applied in standard presses. The process is both practical and economical for boards having a thickness of 1·5cm or more, and it effects a big reduction in processing time. Certain plastic materials, such as poly-vinyl chloride, may be preheated by high-frequency current prior to calendering into sheet, or being made into tube or strip by extrusion processes. Before either calendering or extrusion can be done efficiently the plastic material must be raised to a uniform temperature and the new method of heating is proving to be more efficient than techniques hitherto in use.

The rubber industry makes use of high-frequency current for the preheating of rubber blanks for moulding by compression or transfer, but in some branches of the rubber trade this method of heating is not yet established. A big proportion of rubber goods, such as tyres, contain carbon black, and due to the uneven dispersion of this in the rubber it is not easy to obtain uniform heating with high-frequency current. On a small scale, however, many successful vulcanising tests have been made, but further experimental work is necessary before high-frequency heating can be widely adopted for vulcanising in mass production.

Drying

Since high-frequency current is capable of producing heat equally distributed in a non-conducting substance it follows that the technique can be used for drying various substances. These include timber, textiles,

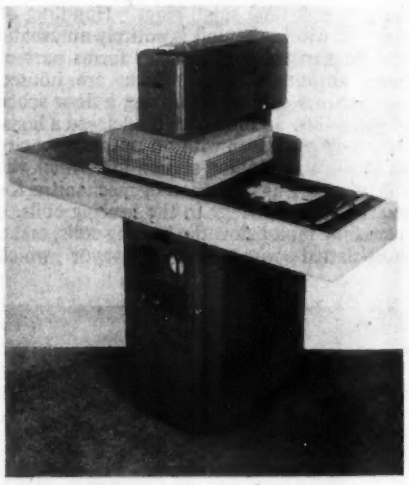


Fig. 8—An Automatic Machine for the Welding of Plastic Materials

tobacco, chemicals, and a variety of powdered materials. In drying such substances the moisture tends to be expelled first from the centre of the product. A proportion of the electrical energy is used up in heating the material itself and so the total power required will vary with the moisture content. Where the timber has an initial moisture content of 40 per cent and it is dried to 15 per cent moisture content, a total power of 42kWh will be needed for every 100 lb of water eliminated. With some materials there is a big reduction in drying time as compared with other methods of drying. For example, in the manufacture of synthetic sponge material the drying time was previously 70 hours, but with high-frequency heating it is only a few minutes. Different materials

having the same water content will vary slightly in the time taken in drying them, but in general for substances containing over 50 per cent water each kilowatt used will remove about 2·8 lb of water each hour. When the initial moisture content is less than this the rate of evaporation decreases, since more of the energy available is taken up in heating the material itself.

In drying processes use is made of two electrodes, so shaped as to cover the material from both sides, and where moisture contents are relatively high the operation is usually carried out in an oven from which the water vapour can be drawn off as it is created. This method of drying is applied to a large number of drugs and chemicals which are vulnerable to ordinary drying techniques.

Factory Regulations for Public Works

(*Contributed*)

IT is probably not generally known that the Ministry of Labour and National Service has under active preparation a new set of Regulations under the Factories Acts of 1937 and 1948, which shall apply to Works of Civil Engineering Construction. So far the proposals have reached the stage of a revised preliminary draft, which was published by H.M. Stationery Office in 1951 for comment by interested parties.

The proposed regulations appear to be merely one further step towards the complete exploitation of employers of labour, with resulting increased costs in all forms of constructional activity. It may well be asked why such interference is considered necessary, and why no evidence has been cited to justify the imposition of so many restrictions on productivity under existing experienced management. If there be proved cases of wilful negligence which have resulted in avoidable accidents, by all means let safeguards be applied, but it appears to be misdirected bureaucracy to invent restrictions in general omnibus terms to cover imaginary cases.

The sequence of events in this exploitation began with the widening of the Factories Acts to include civil engineering operations under an implied, but quite unjustified, assumption that these and building operations could be subjected to similar kinds of inspection and control. Next came the introduction of the Industrial Insurance Scheme carrying with it the abolition of the doctrine of common employment. The Trade Unions were not slow to take advantage of the opportunities thus created, whereby every accident to an employee could be attributed to the negligence of the employer, and the onus of proof placed entirely on his shoulders. The result was to ease the demands on the National Insurance Scheme, with its possibilities of consequent political credit, and to force the employer into additional and separate insurance to cover heavier liabilities under common law.

By this time it had become evident to those in control of the Factories Acts that regulations designed for the building trade would not cover the very different conditions that apply in civil engineering construction. For the former the employers had accepted with comparatively small comment a set of regulations which in effect gave compulsion in most arbitrary and vague terms for safety provisions which most experienced builders already put into practice.

The draft regulations now under review are intended to be the counterpart for the civil engineering industry. They subject the employer to possible injustice, being so contrived that a breach of the regulations with consequent penalties will be incurred if any steps taken by an employer to prevent an accident actually fail in their purpose. The employer will thus be left open to civil action and prosecution for breaches of statutory duty, such breaches being proved by the fact of an accident, no matter what care has been exercised in trying to provide against unforeseen occurrences.

To take a specific example, "all struts and braces in any excavation, shaft, earthwork or tunnel, shall be properly and adequately secured so as to prevent their accidental displacement or fall." Should this displacement occur, despite all precautions, the accident in itself, will prove a breach of duty on the employer's part.

These regulations, if they are promulgated in anything like their present form, will present heaven-sent opportunities for trouble making by the so-called "Workers' Committees," Quite apart from this prospect, however, they will inevitably result in reduced production, increased costs, with the constant menace of litigation, whilst the additional army of factory inspectors required to supervise the industry will be a further tax on the efficiency of works management. It must be remembered that these regulations will apply not only to work done by contract, but to all activity under local government or private enterprise where labour is directly employed on civil engineering construction.

B.T.H. Summer School in Electrical Engineering

THE second B.T.H. summer school in electrical engineering was held at Rugby from July 14th to 18th, and was attended by some forty professors and lecturers from British universities and technical colleges. After the guests had been welcomed by Mr. E. H. Ball, managing director of the British Thomson-Houston Company, Ltd., there was an address by Sir John Hacking, president of the Institution of Electrical Engineers. Abstracts of his remarks are reproduced herewith.

Sir John Hacking : As the emphasis of this course is more on advanced developments in engineering technique, perhaps I might be forgiven if I speak on the general question of technological and technical education. I am all the more justified in doing this, since it is a matter in which the Institution of Electrical Engineers has a very great interest, and, indeed, as the guardian of the standards of the profession, has a very great responsibility. It is also a subject of great interest to me, as a member of the British Electricity Authority, as it is to the manufacturers.

The Council of the Institution, and particularly the members of the Education and Training Committee, are watching with interest two important educational developments which have been made possible by the close collaboration between the B.T.H. Company and the Rugby College of Technology and Arts, developments which perhaps I may be excused for describing as in an experimental stage ; I refer, of course, to the courses for student apprentices reading for the London External Degree and to the advanced courses for graduates. Both have recently been discussed in the Theatre of the Institution and I need not at this moment deal with them further, except to add that the student or engineering apprentice course is an interesting and valuable alternative to the sandwich course advocated by our Education and Training Committee. Its shape leads me to describe it as a Scandinavian sandwich rather than the ordinary accepted British article.

You may also, I think, be interested if I outline briefly the views of the Council of the Institution on the broad pattern of the future provision of higher technological education in this country, and particularly of electrical engineering education, matters which are being so widely debated, and with so great a spread of opinion and competence of expression. The Council is convinced that more effective and wider facilities for technological education should be developed rapidly, as this will have a profound influence on the level of productivity in the United Kingdom, for the rate of increase in productivity is delayed if new scientific discoveries cannot be brought quickly to the stage of effective large-scale application. It is in the detailed engineering steps that lie between scientific discovery and its widespread application in industry that the professional engineer has an important part to play, and there is clear evidence that the present numbers of the right type of man are insufficient and that the number of qualified technologists available each year from universities and colleges must be increased.

It is important to remember that the early provision of more technologists will not alone meet the need. The number of competent technicians must also be correspondingly increased, bearing in mind that the desirable proportions may well be in the ratio of some five technicians to each fully qualified technologist. You will, I think, know that the Council of the Institution fully grasps the importance of this factor and is actively studying, in collaboration with BEAMA and the R.I.C., the special needs of technicians in relation to their education and training. This question is separate from the question of the provision of courses in technology, and it is important that provision should always be made for the transfer of senior technicians to full status as technologists, but it is equally important to encourage men who are better constituted to become technicians of good calibre to qualify themselves in that respect, rather than to attempt to qualify from the outset as technologists.

In the provision of qualified technologists it is the hope of the Council that the universities will continue to play their full part ; indeed, there has recently been evidence of expansion which is encouraging. But despite these developments it may be noted that the proportion of men who graduate in applied science to those graduating in pure science falls far below the national need. It is therefore to be hoped that the recent steps which have been taken in some universities will be followed by others, because the development of technological and advanced technological education in the many-sided environment of a university will produce men of broad outlook, which both the industry and the public utilities in this country will need in greater numbers in future. The valuable leaven which develops through the contacts and discussions between students in different faculties is often seen working to the full in residential universities in consequence of their corporate life. But not all young men who seek to qualify as technologists respond best to the university approach. Others, potentially no less value to industry, make more rapid progress if they have constant contact, throughout their studies, with current industrial practice ; for these men part-time National Certificate courses will continue to represent a most valuable method of training, but, in the view of the Council, these courses should be supplemented by an additional system, which I should like to describe to you in a few moments.

The Council is not enamoured of the idea of a technological "university" on either the E.T.H or M.I.T. pattern, and it is our hope that the developments in existing universities and the up-grading of existing technical colleges, which I shall shortly discuss, will provide the urgently needed facilities for expansion. Quite apart from considerations of certain grave risks attached to this proposed experiment, the Council holds that the time factor does not permit us to regard this as an immediate solution to a very urgent and pressing problem.

Outside the universities the additional facilities should be concentrated and confined to a few

designated technical colleges. The technical colleges of this country have made and are making a valuable contribution to the educational needs of industry, mainly through the medium of their part-time courses. An additional contribution, both at graduate and post-graduate levels, is required of them. This could be met economically by certain designated colleges which should be developed for this purpose, and one of their most valuable contributions would be their specially close liaison with industry. For electrical engineers, the Council feels it essential that these new courses should be industrially based and of the sandwich type. These designated technical colleges could also offer opportunities for higher technological education to past students engaged in industry, and could work at a level comparable in quality with university post-graduate work in particular relation to the needs of the industries whose requirements the colleges more particularly serve.

Activities of this kind require staff and equipment of a high order to provide the conditions necessary for significant contributions to advanced technological research. It is felt, too, that it is preferable that a whole college as a unit, and not individual departments within a college, should be designated and developed. It will also be vitally necessary for the designated colleges to work in close association with specialised colleges within their regions, so that the fullest advantage may be taken of the facilities and industrial connections which they possess.

In these designated colleges the courses must be broadly conceived on a wide basis of fundamental science. Their technological departments cannot flourish alone, but must be sustained by close association with equally extensive and progressive departments of mathematics and physical sciences, and other branches of the applied sciences, all of which must be further sustained by research activity. Attention will also need to be given to the maintenance of an adequate standard of entry in the students they accept.

Another important question is that of control. It seems essential to the Council that the designated colleges should be under a wider control than that of the local education authorities. It is desirable that they should each have an independent governing body, broadly representative, including a substantial representation of industry, so that industry's support in financial and other matters may be encouraged and strengthened. Under an independent governing body the staff will work in an atmosphere of academic freedom, with corresponding advantage to recruitment. It is also important that those with the duty of selecting colleges for designation and for assessing the adequacy of their academic and technological standards must themselves be of high academic and professional status. It follows as a corollary that the designated colleges should be substantially financed from national sources and there is much need for careful planning of the method of allocating these central funds.

We meet at a time when decisions in these vitally important matters are, I hope, imminent. It is the earnest hope of the Council that the contribution they can make from their experience will be heeded and given its full weight. I know that everyone of my audience has these matters very much in mind and I have no doubt that during these next few days much discussion will centre around this general problem.

I would like next to speak, if I may, from the viewpoint of the electricity supply industry. The success of the supply industry is dependent in large measure on the provision by the electrical plant manufacturers of up-to-date equipment at an economical price, and to produce such equipment the manufacturers are in turn dependent on the universities and technical colleges for adequate numbers of well-trained technical staff. We, too, depend directly on the training establishments for staff to plan and operate our equipment. These establishments also render us a further service in the field of research; recognising the value of the best possible scientific advice, the British Electricity Authority has, as you know, appointed a research council, the members of which are drawn mostly from the universities. The Authority has also established a fund from which grants are made to universities and higher technical colleges to assist them in conducting long-term researches of a fundamental character affecting the supply of electricity. Our relations with the training establishments are, thus, of the closest and I gratefully acknowledge the cordial understanding which I think exists between us.

The most important electrical development on which we are now engaged is the 275kV grid. With a transmission line now operating in Sweden at 380kV, and lines approaching or exceeding this voltage being planned or under construction in other countries, it is sometimes suggested that we ought to have adopted a voltage higher than 275kV. Our difficult atmospheric conditions, however, impose on us a special insulation problem and, had we waited for its solution, construction of our higher voltage system would have had to be postponed for at least five years, and urgent major transmission reinforcements, which could not be postponed, would have had to be carried out at 132kV. We considered that would not have been the right course and, in any case, with our relatively short transmission distances, 275kV is the most economic voltage for the amounts of power we are likely to have to transmit during the next ten or fifteen years. We are, however, making provision on the more important lines for an increase of voltage to 380kV should this prove necessary in the future. In the meantime I am confident that the 275kV system which is now being built will both call forth and do full justice to the talents of the research engineers and plant designers of the electrical manufacturing industry.

An interesting project, of which you will recently have seen mention, is the possible cross-channel cable. A joint committee of the British Electricity Authority and Electricite de France have been giving this close study, and have provisionally recommended a 132kV connection with a capacity of 100MW comprising four single-core cables, one cable being spare. Owing to diversity between the system demands and the methods of generation in the two countries, this provision to pass power in either direction is considered to be an economic proposition. Again it may be asked why a higher voltage and higher capacity are not proposed. One reason is that the existing transmission system in the northern part of France is not strong enough to deal with a heavy cross-channel power transfer, which would entail an expensive 220kV reinforcement from a point near Paris. Viewed from the standpoint of both countries, a 132kV connection is the most economic proposition, but we have it in mind that the capacity of the connection could be quadrupled by changing over to direct current transmission in, say, ten years' time. The decision whether to install this cable will not, however, be made until certain research and development work has been carried out and it is estimated that this will take about eighteen months.

Technical Papers

The summer school course consisted, briefly, of twenty-one papers, which were presented by B.T.H. engineers and were discussed informally by the guests. In the first of these papers, "A Plea for a More Physical Approach in the Study of Electrical Engineering," the author, Dr. K. J. R. Wilkinson, D.Sc., M.I.E.E., of the B.T.H. research laboratory, emphasised the importance of the young engineer's formative years at school and at college. Dr. Wilkinson said that before the engineer took up his career, he should be encouraged to think in a logical as distinct from a technological manner; his instruction in the techniques of engineering could safely be left to his later training in industry and to his own receptive interest in engineering things. The author summarised his theme by stating that the graduate engineer, when he leaves college, should know more clearly why three phases are so useful than how to manipulate the algebra of symmetrical components. He should be able by inspection, and without writing anything down, to say whether the balance of any common a.c. bridge is frequency sensitive. He should have an intuitive understanding of circuit impedances quite divorced from their steady state property; that is to say, he should not be blinded by the limited technology of $L\omega$, to the science of Ldi/dt. Above all, he should be encouraged to consider those more philosophical aspects of electromagnetism.

"All this," concluded Dr. Wilkinson, "is ground which you may consider is little short of impertinence for one with no teaching experience to cultivate. My excuse is that in view of current suggestions that the higher teaching of specialised technology is important to our industrial well-being, our experience here is that it is far more important in higher engineering education that the teaching accent should stress fundamentals."

The remaining papers ranged over a wide variety of electrical engineering subjects, including "The Development of Heavy-Current Aircraft Circuit Breakers," by Mr. D. F. Welch; "Parallel Operation of Centimetric Oscillators," by Mr. J. H. Nicoll; "Some Unusual Eddy Current Problems in A.C. Machines," by Mr. K. F. Raby; "Power Transformers for High-Voltage Transmission, with Special Reference to Impulse Phenomena," by Mr. D. McDonald; and "The Contact Rectifier," by Mr. D. R. Smith.

The programme included (on Thursday, July 17th) a discussion on aspects of education and training that are of mutual interest to universities and industries. The discussion was stimulated by being conducted under three specific headings, with opening speakers to introduce each. First, Mr. C. Grad and Mr. C. W. Oatley offered suggestions for arousing interest in science and engineering in the public schools and grammar schools. During the subsequent discussion, an announcement was made that the I.E.E. would be convening a conference for headmasters and another for careers masters during the coming winter. Secondly, Mr. G. S. C. Lucas and Professor M. G. Say posed the question, "Is Graduate Apprenticeship really Necessary?" Thirdly, Dr. W. J. Gibbs spoke about the B.T.H. engineering research fellowship.

During the course of the summer school tours were made of the company's Rugby works, of the research department and electronic engineering department and a visit was made to the Rugby College of Technology and Arts.

Relaxation from a busy technical programme was provided, on Wednesday, July 16th, by a visit to the Shakespeare Memorial Theatre, Stratford on Avon, where the guests were entertained to dinner and to a performance of Ben Jonson's comedy "Volpone."

Books Received

Stahlrohr-Handbuch. By F. H. Stradtmann. Vulkan-Verlag: Dr. W. Classen, Essen. Price DM 29.

Irrigation Engineering. By Ivan E. Houk. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 72s.

Power System Analysis. By Mortlock and Davies. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.

Corrosion Testing Procedures. By F. A. Champion. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

Tungsten. Third edition. By Colin J. Smithells. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

Productivity and Probability. By T. F. O'Connor. London: Emmott and Co., Ltd., 21, Bedford Street, Strand, W.C.2. Price 5s.

Mechanics: Part I, Statics. By J. L. Meriam. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 32s.

Wire Rope Lubrication. By E. V. Patterson. Shropshire: Scientific Publications, 8, Walker Street, Wellington. Price 3s.

Die Wasserschliefsung. Compiled by H. Schneider, C. Truelsen and H. Thiele. Vulkan-Verlag: Dr. W. Classen, Essen. Price DM 68.

Chronicles of a Country Works. By R. H. Clark. London: Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 63s.

Strength of Materials. By John B. Thirlwell. London: Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 20s.

Structural Analysis of the Dome of Discovery. London: Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 25s.

Wind Tunnel Investigations on Rotating Blades of Aerofoil Section*

By K. H. KHALIL, M.Eng., Ph.D., A.M.I.Mech.E.†

The results are presented in this paper of investigations on the pressure distributions around Aerofoil section blades rotating in a wind tunnel. The experimental difficulty of obtaining pressures during rotation was overcome by the use of a special gauge attached to the hubs and illuminated by "stroboflood" for direct observation. Pressure diagrams and lift coefficients were obtained along the radius of a double-blade set, arranged as a windmill, for various angles of incidence. Static tests were conducted also in all cases to find values for comparison. As the purpose of the work was to contrast rotating and static conditions, two main facts are emphasised: the similarity in the pressure diagram shapes and the significance of the spin factor. It therefore becomes possible to correct ordinary test results obtained when using stationary aerofoil blades in wind tunnels by adding the effect of a vortex of rotation of uniform strength.

Introduction

The main purpose of these investigations was to compare the pressure and lift characteristics of a rotating blade with those obtained for the same blade type when at rest, and thus to determine how far the relatively simple procedure necessary for static tests might assist in the more difficult case of rotation.

It was known that the results obtained from tests on fixed aerofoil blades could not be applied directly to moving blades, owing to a distinct contrast between the static and rotational conditions. In rotation the flow in the blade passage behaves differently, because of centrifugal action. The change of incidence angles and the tangential component at different radii resulting from rotation causes a variation in lift and circulation along the blade, which creates a distribution of trailing vortices different from those expected in direct static tests.

Although this phenomenon is of great importance in the design of blading and must be taken into consideration for good efficiencies, the literature dealing with it is meagre. It would therefore seem necessary to explore the connection between stationary and rotating aerofoil blades before reaching a conclusion on the possibility of deducing the characteristics of rotating blades from simple static tests.

The arrangement of blades used in the present investigations resembled that of a windmill rotated by axial air flowing in the wind tunnel; other arrangements of blading, such as those for turbines or compressors, could be investigated with a similar experimental technique to that applied here.

As the investigation was mainly concerned with the points of contrast between stationary and rotational conditions, effects that might be considered common to both did not need special attention. The chief difference is due to spin and therefore an investigation of the spin factor was the main requirement.

It is realised that the present investigation has a limited application and that it would have to be extended over a wide range of blade forms and conditions to allow general treatment, but it is possible that a consideration of the leading features of these results may help to guide a further experimental programme.

Technique of Experiment

Development of this class of experiment has been delayed by the difficulty of measuring pressures on rotating elements. The ordinary method of transferring the pressure from the rotating element to the stationary measuring gauge through glands and tubes does not secure sufficient air-tightness and accuracy when measuring such small pressures as those in air flow tests.

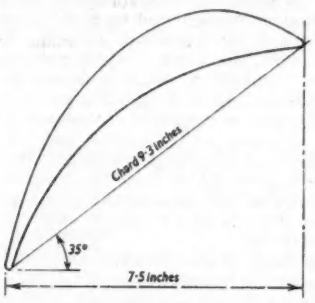


Fig. 1—Blade Dimensions

All experiments described here depended upon a technique that overcame this difficulty by using a self-contained rotating unit illuminated for stroboscopic determination, by having the pressure measuring instrument fixed to the rotating element to form one body. The pressure gauge chosen was of the diaphragm type and was designed specially for these experiments to stand centrifugal forces on its elements at speeds of up to 1000 r.p.m.

The diaphragm gauge was embedded centrally in the boss so that its dial and diaphragm were parallel to the plane of rotation. As the mechanism inside was well balanced, its centrifugal force had no effect on the readings of outside pressure connected to the diaphragm chamber. That could be checked by rotating the gauge, without any outside connection, at the speeds guaranteed, and ensuring that there was no deflection of the pointer. The gauge was read conveniently during rotation, by means of a powerful "stroboflood" connected in parallel with a comparatively small "stroboflash" that regulated its frequency; an arrangement that provided a considerably greater light than normally obtained for photographic purposes and flood-lit areas. To enable the gauge to be read conveniently, a "contactor" was used to synchronise the flash frequency with the rotation of the blades and thus eliminate the need for further adjustments for variations in speed.

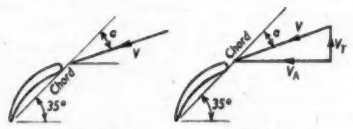


Fig. 2—Conditions of Tests

The essential apparatus consisted of the 5ft diameter open-jet wind tunnel at the Royal Technical College, Glasgow, a motoring machine to rotate the blades, and two aerofoil blades forming a blade-set mounted on a suitable hub. Such an arrangement prevented interference by neighbouring blades, which would have disturbed the flow and imposed effects other than those due to rotation.

For reasons of balance, the two blades were placed in the same sense, or in other words in aerodynamically similar positions. One blade only contained pressure tubes; the other was present solely for balancing reasons. The "pressure" blade had small copper tubes embedded in its body and made flush with the surface; pressure holes of $\frac{1}{32}$in diameter were drilled in the tubes at the different sections. The two blades, each 2ft long and with chord dimensions as shown in Fig. 1, were held together and to the boss by a bolt 4ft 8in long, which passed through their centres and the hub. In the normal position the blades were fixed with their chords at an angle of 35 deg. to the axis. To change that angle of incidence, as would be required for static tests, the blades were merely turned round the bolt to the desired extent, and the bolt was tightened rigidly and locked from both sides. The blades were then mounted on the shaft of the motoring machine, which ran freely on two thrust ball bearings and was supported on an I-beam fixed to the frame; owing to its web being small the least resistance was offered downstream behind the blades when they were in the lowest position. A 3·5 h.p. d.c. motor was used to drive the blades at a speed varying from 50 to 800 r.p.m., with a belt drive to provide for reverse direction. The frame was mounted on two wooden logs 18in by 18in, to absorb vibrations.

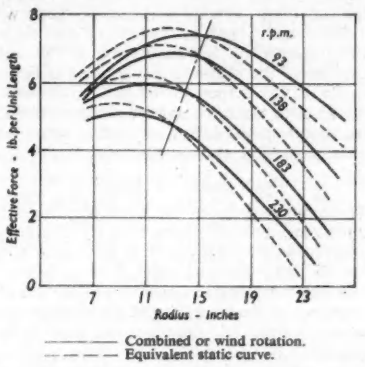
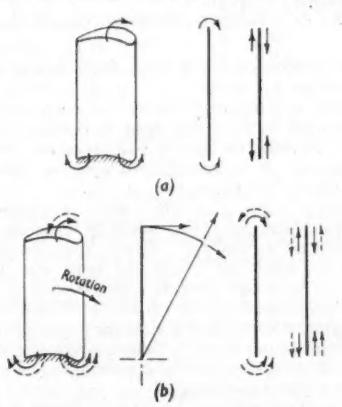


Fig. 3—Effective Force Curves Taking into Account Change of Relative Velocity

Experimental Procedure

The main procedure followed was to carry out two series of tests for comparison; in the first series, the pressure distribution was measured on the blade when stationary, with the wind blowing at various incidences; in the second series, the pressure distribution was again measured, but while the blade was rotated with the wind blowing axially. In other words, the various incidences were obtained by changing one or both of the two flow components—namely, the tangential component due to rotation, and the axial component due to wind.



(*a*) With reference to the blade. (*b*) Effect of rotation.

Fig. 4—Movement of Air over Blade

In order to have the same conditions of comparison the resultant relative velocity in the second case had to be equal to the wind velocity on the static blade at the same incidences. The diagrams shown in Fig. 2 contrast the conditions for testing in static and combined cases. It

Notation

a	Inflow factor.
b	Spin factor.
B	Number of blades.
c	Chord Length.
C_D	Drag coefficient.
C_E	Effective force coefficient.
C_L	Lift coefficient.
D	Drag per unit length of span.
K	Coefficient of integration.
l	Length of span.
L	Lift per unit length of span.
N	Speed in r.p.m.
P	Pressure as measured in inches of water.
r	Radius.
S	Rotational vortex strength in square feet per second.
T	Thrust.
V	Relative air velocity in feet per second.
V_T	Tangential velocity component of rotation.
V_A	Axial velocity component (wind).
V'	New resultant velocity as deduced graphically.
α	Angle of incidence.
ϕ	Angle relative velocity makes with axial direction.
ρ	Air density.
Γ	Circulation in square feet per second per unit length.
Γ_{rot}	Circulation for wind tests.
Γ_{st}	Circulation for static tests.
ω	Angular velocity of blades.

* Institution of Mechanical Engineers. Extract. Written discussion is invited by the Institution, communications to be received by September 11, 1952.

† Senior lecturer in Faculty of Mechanical Engineering, Fouad I University, Giza, Egypt.

should be noted here that the axial component (wind) as shown in the figure was always measured just before the plane of rotation in order to take into account the change of air velocity due to flow interference. The measurement was made by means of a special small pitot tube placed near the mid-span section to allow for the very slight variations along the radius.

After arriving at the same relative velocity in magnitude and direction, it should be possible to compare the tests on stationary and rotating blades, mainly by the assistance of the shapes and areas of the pressure distribution diagrams ; a study of the shapes shows to what extent the flows in both conditions were similar, while the areas represent the lifting or useful forces which can consequently also be studied.

Discussion of Results

The main purpose of the work was to contrast the pressure and lift characteristics of the aerofoil blade when rotating in a wind tunnel with those obtained when at rest, all other conditions remaining the same in order to isolate the effect of rotation, so that it would be possible to correct results obtained by simple static tests in wind tunnels.

It is perhaps unfortunate that the section used had such a high camber, as the points of differences would probably have been less confusing with a flatter type ; experimental work was facilitated, however, by the fact that these blade-forms already existed and some results had already been obtained from them in an earlier investigation. In spite of the high camber, the features of similarity between static and rotating results are striking and lead to certain conclusions of value as regards both pressure and lift diagrams. It is intended to examine these in this part of the paper.

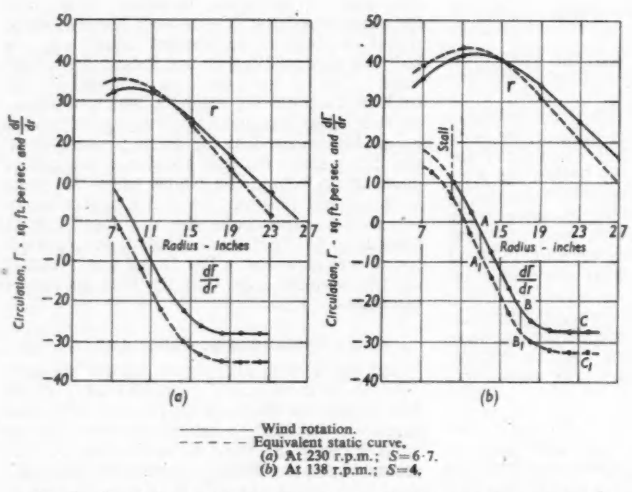


Fig. 5—Circulation and Vortex Strength per Unit Length Along Blade Axis

Comparison of static and wind-rotation pressure diagrams is best made by superimposing corresponding curves. Apart from the differences in areas, the shapes of both are closely similar, with the exception of the loop portion in some of the diagrams. It should be emphasised however, that similarity of shape does not necessarily mean the same coefficient of lift or effective forces, for static and rotating conditions with the same angle of incidence.

The effective force distribution diagram along this straight uniform blade is a form of lift-incidence curve. It starts from the tip side with small incidences, rises in a straight line manner, stalls after a certain angle or radius, and has a maximum for each speed of rotation. Comparison of these diagrams for static and rotating conditions is clearly illustrated by Fig. 3, which is actually the most useful diagram of results in these tests on the double-blade arrangement.

As the paper is mainly concerned with the points of contrast between the static and rotating conditions, effects that might be considered common to both need not receive special attention. It should also be noted here that the small effect of the inflow factor is eliminated in these experiments as the axial wind component was measured just before the rotating blades. Thus, the chief influence is largely due to spin and an examination of the spin factor is the main requirement.

Comparison of diagrams of static and combined effective force distribution along the blade —as given in Fig. 3—shows that rotation causes a positive effect or an increase in the effective force at the outer radii, accompanied by a negative effect or a decrease at the inner radii. This can be explained in a simple way if the blade in this case is considered as an aeroplane wing with a short span. The average pressure over the concave or front side of the blade must be higher than that over the back side. When consideration is given to the section between the mid-span and the edge, whether along the back or front sides, the same pressure is reached ; thus, there is a drop in pressure outwards along the front side towards the edges and a further drop inwards from the edges towards the mid-span section, This effect, which is sometimes called " tip leakage," has a direct influence on the pressure distribution diagram ; it decreases the area of the diagram, with the result that the lift or effective forces are always smaller near the edges ; the root section of the blade near the hub could be considered to behave nearly as a blade edge because there is also a leakage effect from the sides of the hub.

Since the air is urged in the direction of decreasing pressure it follows that an air particle which impinges on the leading edge and passes over the back of the blade acquires a velocity component parallel to the span and towards the mid-span section, Fig. 4*a*. A corresponding particle which passes over the front or pressure surface acquires a velocity component parallel to the span but away from the mid-span section.

When the blade rotates it strikes the air with its convex, or back, side, forcing the air to rotate also; this rotation entails a radial component that is due to continuous change in direction, and each air particle will be subjected to a centrifugal effect outwards, Fig. 4*b*. Some of the air flowing radially in front of the rotating blade enters the vacuum left behind it ; it thus counteracts the flow caused by the leakage effect near the tip edge and results in an increase in the lift or effective forces at the outer radii, which are due to rotation.

The opposite occurs at the root sections, where the leakage effect is probably assisted by the radial flow and results in a further decrease in the lift which might be used to explain diagrammatically the comparison curves in Fig. 3.

In comparing the effective forces in the rotating and static conditions, the distinctive influence of rotation on the maximum lift and on the slope should be considered further. It will be noticed that the maxima of the combined curves are lower than their equivalent static values and that this reduction increases noticeably as the speed increases. The differences in slope of the rotational and equivalent static curves would appear to be more definite.

As the slopes of the curves of circulation have more significance than those of effective force, it seemed best to change to curves of circulation before examining the gradients. Lift $L=\rho V\Gamma$ per unit length of span, or $\Gamma=L/\rho V$, where Γ is circulation in square feet per second per unit length, V is relative air velocity in feet per second, and ρ is density of air in pounds per cubic foot.

To determine the circulation curves, however, the effective forces per unit length, as used in the diagrams, were taken. As the necessary correction to this approximation affects all results similarly, comparisons are not upset.

When curves of circulation Γ against the radius r are plotted for both static and combined results at speeds tested before—as shown in the upper portions of Fig. 5*a* and *b*, where speeds of 230 and 138 r.p.m. were taken as examples of the general procedure—it appears that these circulation curves have the same shape and features as the effective force curves. It should also be stated here that the value of the relative air velocity V, as used in obtaining Γ, was equal to 70ft per second at the mid-span section, and that it increased for the bigger radii and decreased for the smaller radii as stated before.

Slope, or Vortex Strength Curves.—The problem under consideration can be summarised in the following heads : (1) an aerofoil blade with short span ; (2) wind flowing at different angles of incidence at each radius when the blade is rotated ; and (3) smaller incidences near the tip edge as the blade is uniform.

It is obvious that there must be some difference in lift along the blade owing to the change of incidence and the tip leakage at the edges. This has been verified by experimental work.

Circulation also changes along the blade span, and entails a system of vortices, distributed in the following way.

If, between sections of radii r and $(r+dr)$ in Fig. 6, circulation falls by the amount $-\frac{d\Gamma}{dr}dr$, a trailing vortex of this strength must spring from the element dr of the blade span. Therefore, the vortex strength per unit length of span will be equal to $-\frac{d\Gamma}{dr}$, or the slope of the circulation curve at the section concerned.

When the blade is rotated a different distribution of lift is to be expected, and hence the circulation will be different—as is supported by the experimental results ; this will also give a system of vortices different in strength from that encountered in the equivalent static tests. A study of this difference and its relation to speed should give a clue to the rotational effect on the aerofoil blade characteristic.

The circulation curves for static and combined conditions were then differentiated, by determining the slopes at the different points, and the results were plotted on the circulation graphs as shown in the bottom parts of Fig. 5*a* and *b*.

The $d\Gamma/dr$ curve starts with positive values at the root side, decreases to zero at the point corresponding to a maximum circulation, and then continues on the negative side with increasing negative values until a " saturation " is reached

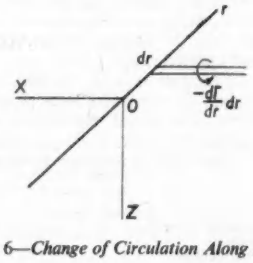


Fig. 6—Change of Circulation Along Blade Span

where $d\Gamma/dr$ remains a negative constant that corresponds to the straight line portion of the circulation curve at the outer radii.

The two $d\Gamma/dr$ curves for static and rotating conditions do not intersect and are nearly parallel to each other throughout their full lengths. The vertical differences between them are found to be equal for the whole length of the blade : $AA_1=BB_1=CC_1=$constant S, as shown in Fig. 5*b*, and similarly but with different constants for the other speeds. This leads to the conclusion that there is a constant difference between the rate of change of circulation with respect to the radius for static and combined conditions.

When the constant difference S was plotted against the r.p.m., it was found to show a straight line relation, as in Fig. 7.

As the slope of the circulation curve $d\Gamma/dr$ represents the strength of the trailing vortex per unit length at the radius concerned, a constant difference between the gradients appears to

indicate an added vortex, uniform in strength and direction, caused by rotation : $\frac{d\Gamma_{rot}}{dr}=\frac{d\Gamma_{st}}{dr}+S$, where Γ_{rot} is the circulation for wind rotation tests in square feet per second per unit length, Γ_{st} is the circulation for static tests in square feet per second per unit length, and S is the rotational vortex strength which is dependent on the speed and independent of the radius.

The effect of rotation can thus be considered as equivalent to a vortex of uniform strength, magnitude, and sense, superimposed upon or added to the ordinary system of vortices distributed along the blade when it is stationary.

Deduction of Spin Factor.—When an element ring at radius r of the rotating blades is considered, with area $2\pi r dr$, angular velocity of blades ω, and spin in the field $b\omega$ (where b is the spin

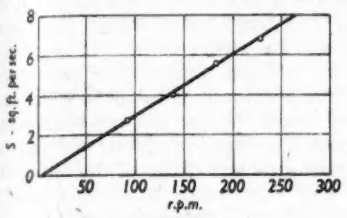


Fig. 7—Straight Line Relation of S and r.p.m.

factor), the vorticity in the field $=2b\omega$, and the circulation in the ring = vorticity × area or $=2b\omega\times 2\pi r dr=4\pi b\omega r dr$.

When the circulation per unit length is considered as before, $\Gamma=4\pi b\omega r$ (a straight line relation), and $d\Gamma/dr=4\pi b\omega$; that is, the system of vortices caused by rotation alone is uniform in strength, or the rate of change of circulation caused by rotation alone is a constant and depends on speed but is independent of the radius.

When the experimental results are considered, it can be said that $d\Gamma/dr$ for the rotating condition is $4\pi b\omega$ greater than for the static condition, that $\frac{d\Gamma_{rot}}{dr}=\frac{d\Gamma_{st}}{dr}+4\pi b\omega$, and $S=4\pi b\omega$ $=4b\times\frac{2\pi N}{60}$, as the spin factor $b=\frac{S\times 60}{8\pi^2 N}$. When S and N from the straight line relation in Fig. 7 are substituted, the spin factor b for the double blade used here $=0{\cdot}0225$ or $2{\cdot}25$ per cent.

Consideration of Blade Element Theory.—In this theory the blades are considered as made up of a number of small elements and the air forces on each element are calculated. Each element has a negligible " span " in the ordinary sense, but at the same time it forms part of a long aerofoil.

It is also considered that the interference on the two-dimensional flow can be represented by an axial interference velocity $V_A a$ and a rotational interference velocity ($b\omega$) as shown in Fig. 8. The condition studied is slightly different from that usually treated, as the blade is not developing thrust to any extent. For this reason it is possible to develop the interference factor due to spin without much concern for the inflow factor.

In effect the Glauert theory, combining blade element and momentum conditions, represents a separate determination of the two factors and the present treatment amounts to a special consideration of one of these.

The conditions are as in Fig. 8, which shows an element at radius r at its angle of incidence α, with spin factor b, and inflow factor a. Then dP/dr is the force per unit length in the direction of rotation and dT/dr is the thrust per unit length perpendicular to direction of rotation.

Hence :

$$\frac{dP}{dr}=B\rho/2V^2c(C_L\cos\phi-C_D\sin\phi)$$

$$\frac{dT}{dr}=B\rho/2V^2c(C_L\sin\phi+C_D\cos\phi).$$

By use of the usual momentum consideration, that the changes at the disc are one-half of those downstream,

$$\frac{dP}{dr}=\rho(2\pi r)V(1+a)2b\omega r$$

$$\frac{dT}{dr}=\rho(2\pi r)V(1+a)2aV$$

When the standard result is used it easily follows that

$$\frac{b}{a}=\frac{\cos\phi(C_L\cos\phi-C_D\sin\phi)}{\sin\phi(C_L\sin\phi+C_D\cos\phi)}$$

which means that for normal incidences b is much greater than a. Consequently, a may be neglected as b itself is not very large.

From the two expressions for dP/dr :

$$\frac{B\,.\,c}{2\pi r}\times\tfrac{1}{2}\times\frac{1-b}{\sin\phi}(C_L\cos\phi-C_D\sin\phi)=2b\cos\phi.$$

Therefore

$$b=\frac{1}{1+\dfrac{4}{\dfrac{B\,.\,c}{2\pi r}\times\dfrac{C_L\cos\phi-C_D\sin\phi}{\sin\phi\cos\phi}}}.$$

But $B\,.\,c/2\pi r$ is equal to the solidity ratio σ.

Therefore

$$b=\frac{1}{1+\dfrac{4}{\sigma\times\dfrac{C_L\cos\phi-C_D\sin\phi}{\sin\phi\cos\phi}}}$$

which shows that b is independent of ω or speed.

Correction of Static Lift and Circulation.—From the previous analysis, $\frac{d\Gamma_{rot}}{dr}=\frac{d\Gamma_{st}}{dr}+4\pi b\omega$ and, when integrated,

$$\Gamma_{rot}=\Gamma_{st}+4\pi b\omega r+K$$

The constant of integration K can be determined by considering the radius (r_0) where

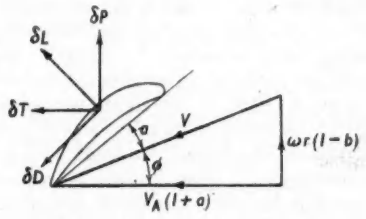


Fig. 8—Conditions of Experiment

rotational and static circulations are equal or the point where the two circulation curves intersect ; r_0 is very near to the mid-span radius as in these series. Then,

$$\Gamma_{rot}=\Gamma_{st}+4\pi b\omega(r-r_0)$$

This expression represents the circulation during wind-rotation tests or the actual performance of blades in practical use, and it is formed of two terms ; the first is the static circulation as obtained from the simple tests carried out on similar areofoils in wind tunnels ; the second or correction term includes the effect of rotation, the speed effect ω, and the spin factor b, obtained by the analysis given before.

Conclusions.—The experiments described in this paper, involving the use of the usual pressure tubes and an attached gauge illuminated by a " stroboflood," are considered to give a satisfactory and successful way of investigating pressure distributions on rotating blades. The experimental possibilities of the method are considerable, as almost any kind of blade could be examined in this way.

Experiments described in the first part of the paper disclose the close similarity in shape of the pressure diagrams at the same incidence and position for static and rotating conditions ; the divergence from similarity occurs only at the loop portion at small angles, for which the blade type is naturally unsuited.

The pressure diagrams at the different radii of the rotating blade are similar in shape to the corresponding static diagrams ; but the lift and circulation values are different as they are less at the inner and greater at the outer radii. The difference is shown mainly in a change in gradient, which is independent of the radius and proportional directly to the speed.

When the system of trailing vortices is contrasted for both rotating and equivalent static conditions, it is found that there is a constant difference along the blade span, which depends on the speed of rotation. It is suggested that this is caused by an added uniform vortex strength, which incorporates the effect of the spin factor and is the true indication of the result of rotation.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BRITISH LOCOMOTIVE PERFORMANCE AND EFFICIENCY TESTS

SIR,—In his letter in your issue of July 18th, Professor Tuplin demonstrates an error which Mr. Nock has made in assuming that a locomotive with a lower specific coal consumption at 70 m.p.h. than at 50 m.p.h. will run more economically at 70 m.p.h.

This assumption seems to indicate some confusion between the behaviour of a locomotive as a means of generating power and a locomotive as an apparatus for consuming power. One wonders whether the authors of the bulletin which Mr. Nock was describing have not fallen into a similar trap in prescribing most economical steam rates. One sees in the bulletin that the " B1 " mixed traffic locomotive is expected to run most economically at a steam rate of about 16,000 lb per hour, and I think this most unlikely.

I have recently carried out a small calculation on the running of a " B1 " locomotive hauling eight passenger coaches between Keighley and Skipton at different steam rates, the lowest being 9000 lb per hour, and have found that the lower the steam rate the less coal used between the two points. There was no sign of a minimum coal consumption having been reached. This seems to be in direct conflict with the statement that 16,000 lb per hour is the most economical steam rate, and I should be interested to see how the two results can be reconciled.

G. T. SMAILES

Bingley, Yorks,
August 2nd.

TRUE TO TYPE

SIR,—As one who, for his sins and, incidentally, in the course of his duties, has to read from cover to cover—advertisements included—every technical and trade paper of any note, may I offer congratulations on your change in type face ?

It is pleasant to think that, in the technical world at least, a journal is prepared to consider the comfort and convenience of its readers and, at the same time, help to reduce the enormous expenditure on National Health spectacles !

A. L. LATCHFORD

Buxted,
Sussex,
August 1st.

THE FUTURE DEMAND FOR COAL

SIR,—It appears that the contributions under the above heading have gone very far from the point I tried to make in my first letter, that short-term forecasts of the future demand for coal in common with most other things do not usually represent the best method of estimating.

Your correspondents now seem to be concentrating on back-pressure generation, and I would refer them to an article on page 33 of the August issue of the *Times Review of Industry*, which I think they will find discusses the subject very fairly and in an unbiased way.

Mr. Fox tells me something I had heard about, namely, that experiments in the carbonisation of low-grade fuels are going ahead, but he does not tell me to what extent this is being done, nor why it was not done in the past.

Finally, can he answer this one ? If the manufacture of gas produces coke, benzol, tar and all the other by-products for which there is presumably a sale, why are gas and coke so expensive ?

R. E. GAMLEN

Brighton,
Sussex,
August 8th.

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BROADENING EDUCATION

Since we have for long believed and pleaded that the technical education of engineers should be broadened to include subjects outside immediate specialisation in engineering, we welcome the arrangement recorded upon another page of this issue by which the Imperial College of Science and Technology in South Kensington and the London School of Economics and Political Science are to collaborate in the provision of post-graduate courses. The education that students of engineering receive at Universities is often criticised by industrialists on the grounds that it is too narrow ; and that, in consequence, graduates cannot quickly and easily adjust themselves to industrial conditions. Notably—for is it not evidence of a lack of reading in good literature ?—there is frequent complaint that graduates are incapable of writing or even expressing themselves in clear English. To criticisms of that kind professors reply that industrialists expect too much ; that though a broadening of the education might indeed be valuable there is so much fundamental technical material to be taught that time cannot be found to teach other subjects, too; that a sound knowledge of some subjects (notably the writing of English) ought to have been acquired before entry to the University ; and that knowledge of others is better left to be acquired after leaving it. The arrangement now made between the Imperial College and the London School of Economics goes some way to meet the ideas and criticisms of both parties. For though engineering students who follow courses under the scheme, in economics or similar subjects, will certainly have deepened and widened their education, the courses concerned are available only to graduates. The bulk of those trained in science and engineering at Imperial College will unfortunately be less effectively influenced through the liaison thus established between these two educational bodies.

One of the difficulties that those who criticise technical education encounter is that of choosing out of the very many possible subjects what "cultural" study should be included to broaden a technical curriculum. Shall it be social or political history? Or one or more of the arts? English literature ? A foreign language ? Law ? Administration ? Management ? Or should an attempt be made to include several such studies in more elementary form ? For our part, if it lay with us to choose a single subject not too far divorced from engineering, it would be "economics." The student of engineering, who necessarily concentrates in his academic education on theoretical calculations is liable to acquire two related and erroneous impressions that have to be discarded in later life. The first is that he may pay exaggerated respect to technical efficiency to the exclusion of other factors vaguely defined as convenience in use, ease of maintenance, simplicity and reliability which are at least as important in making engineering goods saleable and usable. The other is that he may neglect the economic factor, that factor that makes it necessary, for instance, to build a power station to be not as thermally efficient as its site permits but cheapest in producing power at that site, a very different thing. The study of economics can quickly correct such misconceptions. Furthermore, correctly taught, it can bring a student to understand that what can or cannot be made and sold depends upon what amounts of money individual human beings are prepared to spend upon what goods. He is thus led to glimpse the need, for a successful life, of gaining some understanding of the workings of human nature so that in fields where exact mathematical calculation is not possible good judgment may be exercised in reaching a decision about the probabilities. The researches projected under the schemes the Imperial College and the London School have devised are expected to "throw light on the direction, strength and interplay of scientific, technological, social and market forces" and even where the purpose is only to assist post-graduate students "to broaden and deepen their education and training" opportunities are to be given to scientists and technologists to study "labour, finance, marketing and other aspects of industry." Can there be any doubt that engineers with the broader experience provided by these courses will be more immediately valuable in industry than those whose academic training has been confined to technicalities ?

The scheme has a further value. Those who are scientifically trained are constantly meeting others, often in superior positions, who not only know nothing of science but seem to believe, even though applied science influences almost every human activity, that there is no need for men in high positions to have any knowledge of it. Yet those same people, suffering though they undoubtedly are from a seriously unbalanced understanding of human life, are amongst the foremost of those who criticise scientists and engineers for their little knowledge of the humanities and arts ! It seems to us as valuable a quality of the arrangements made by the College and the School that graduates of the latter shall be able to experience courses "designed to illustrate typical developments in science and their application to industry" as that graduates of the former should acquire introductory knowledge of economics, law, history and administration. Nor does it seem to us that graduates will be the sole gainers. Members of all the faculties involved are likely to profit by a form of co-operation which may lead to lively discussion between them. Sir Roderic Hill, Rector of the Imperial College, Sir Alexander Carr-Saunders, Director of the London School of Economics, and all the professors and others who have helped to set the scheme going, are, we think, to be congratulated upon an achievement which should prove of lasting value to all concerned.

THE DESIGN OF FAIRGROUND MACHINERY

A very large amount of mechanical equipment is constantly in use in amusement parks and fairgrounds in this country. Much of it is designed not only to amuse but to thrill patrons. We hesitate to be dogmatic upon the point—psychologists have no doubt studied it—but from experience we judge, too, that much of the equipment is designed rather to frighten than merely to amuse ! Certainly those whose joy it is to descend by erratic down and up motions at varying speed under gravitational acceleration from the top of a "Giant Racer" to the gratefully solid ground below look with contempt upon others who, after a single trial, leave well alone ! But the degree of fright must be limited. Those who come off the chairs of "The Whip" must feel they have acquired merited applause for their courage, but they must not emerge white-faced, shaking and trembling and swearing never again to repeat the experience! In short, dangerous though fairground machinery may appear to be, it is in fact essential that it shall be safe. For in reality any kind of accident creates the worst kind of publicity, that which makes patrons stay away.

It speaks very highly of the skill and care of manufacturers and operators of such peripatetic machinery as that found in

fairgrounds that accidents like that which occurred recently at Alexandra Park and which received so much publicity in the evening and daily press are so very rare. With the possible exception of engineers, who, we notice, are just as little able to resist the attractions of a fairground as anyone else, few pleasure seekers take more than a very casual interest in the mechanical side of the many ingenious devices they are asked to patronise. That is a pity. For in the development, manufacture and operation of fairground machinery unusual requirements have to be met. The devices must not only look attractive, amusing or exciting. They must also be simple in construction, easy to dismantle into pieces small enough to be transported elsewhere, light in weight and easy to maintain. Above all, once erected and in operation, somewhat dangerous though they may, excitingly, appear, they must be safe, safe even against fools who will, unless prevented, stick out arms, elbows and legs when they would be better kept inside ; safe against the indiscretions of those who have looked upon the wine when it was red ; and safe even against the possible human failings of those whose job it is to operate them. Those requirements are met by simplicity of construction—an essential in a device that may have to be erected or dismantled very quickly upon an awkward site under unfavourable conditions of light and weather—and by restricting the size and weight of separate parts to facilitate handling. But individual units must be not only compact in size. They must also be robust in design to stand up to frequent handling and to avoid any distortion that might prevent one unit lining up with its fellow. Inspection and maintenance are facilitated by the very fact that the device has so frequently to be dismantled and re-erected. The whole must withstand rough treatment, including that which it is likely to suffer from our inclement and unpredictable weather. It is obvious enough that the designer and builder of such machinery has no simple task.

It is at first sight a surprising fact that this class of machinery has rarely if ever been fully described in the technical press. There are two reasons why it has not received attention. First, the design of the greater part of the machinery stems from only two sources. A large number of the seemingly very varied devices seen on a fairground are closely similar in design to the ordinary roundabout. The lineage of the rest can be traced back to swings. By ingenuity, by good window-dressing, and by combining features from both stems, designers of fairground plant have succeeded in adding many new attractions to the basic roundabouts and swings. Yet the designs of the machines still depend fundamentally upon very simple arrangement of wheels, rails, cams and levers, and the exhilarating effects felt by patrons mostly derive from unusual combinations of centrifugal force and gravity. But that basic simplicity of construction would not by itself have prevented occasional accounts of fairground machinery appearing in the press. There is another factor. It is that in the design of fairground plant operator and designer work closely together in designing something that will be made to standards of strength and with materials that have long since been found by experience to be satisfactory. Moreover, many new pieces of fairground machinery are likely to be special in the sense that no other identically the same will be made. In those circumstances an author setting out to write a description of fairground machinery is only too likely to find that no drawings and no detailed specifications are in existence. For either they have not survived or—more probably—they never existed in any form higher than that of a rough sketch and some scribbled instructions ! Accurate engineering drawings are not needed. Indeed, it may be doubted whether the operator, upon whose decisions and experience the final appearance of the device will depend, would trouble to understand them if they were produced. The majority of the few firms that undertake this class of work seem to be small and individual in character ; and in the work of their employees there survives some of the skill of the millwrights of old. For such men it is sufficient to be given a rough sketch, provided that they can occasionally discuss the design, as the machine develops, with the man who is to operate it. Would there survived more such men in Britain ! Theirs is a skill that is dying out in other fields.

Literature

The Principles of the Control and Stability of Aircraft. By Professor W. J. DUNCAN, D.Sc., F.R.S. London : Cambridge University Press, 200 Euston Road, N.W.1. Price 40s.

WHEN the Government College of Aeronautics was established immediately after the second world war there was some uncertainty as to its probable future status, and it is comforting therefore, to find that its present Head is able to claim, in his foreword to this book, that its teaching is now at post-graduate level, and that every endeavour is made to take students to the frontiers of existing knowledge in the wide field of aeronautics. Mr. Relf who is also general editor of this series of volumes to be issued by the Cambridge Press, expresses, in this first of the series, the hope that its successors will appear at not too infrequent intervals and be able to play an important part in extending the range and the general availability of aeronautical literature.

Professor Duncan, the Mechan Professor of Aeronautics and Fluid Mechanics in the University of Glasgow, has chosen for his volume a mathematical topic which has increased much in complexity in recent years, mainly through the growth of the incidence of air compressibility effects and in the deformation, due to advancing airspeeds, of the structural members of aircraft. The author acknowledges his indebtedness to Professor A. D. Young for chapters on " Stalling and the Spin " and on " Flaps for Landing and Take-off " ; the other thirteen chapters deal with methods of investigating stability, flap control in general, the measurement of aerodynamic derivatives, the study of manœuvrability and the influences (already cited) of distortion in structure and of air compressibility. In his earlier pages the author emphasises the importance of the physical qualities of human pilots, notably the amount of muscular strength required of them and the length of their reaction times to touch, sound and sight, which are of increasing importance as airspeeds reach higher levels and seem about to increase even further. It is interesting that the author finds the normal human reaction times to touch or sound to be as long as 0·12 second, and for visual stimulus to be about half as much again ; whereas the response of the elements of the aircraft structure itself can be so much more rapid. He takes the robust view that, although almost any conceivable innovation in the design of controls is sure to be disliked at first by a large proportion of pilots, this repulsion is gradually allayed, through education and experience, if the innovation proves itself to be intrinsically good. The chapter concerned closes with the warning, attributed to the great Cambridge physicist, J. J. Thomson, that " a scientific theory is a policy rather than a creed."

As is natural in a treatise intended for post-graduate study, the treatment assumes a ready acquaintanceship with mathematical technique, and in the field of aeronautics that would certainly be expected. In some cases, however, as in the study of spinning, the phenomena are so complex that it comes as a welcome relief that a check is obtainable through the device of the free spinning vertical tunnel which was originated in the inter-war years at Farnborough. (A second was soon afterwards built in U.S.A.) In its initial form this tunnel was of modest dimensions ; but, even so, it proved of very great service, as it enabled a freely flying model to spin steadily at eye level for just as long as might be wished, and then to have its controls moved, whether by clockwork or by remote control of some sort, in such a way as should end the spin, and allow the change in the resulting motion to be studied. A description and illustration is given of the much larger spinning tunnel to be employed at the National Aeronautical Establishment at Bedford. As the author points out, this later tunnel is planned, by current standards, on ambitious lines ; the power required for the vertical air jet is no less than 3000 h.p., whilst the tunnel itself can be pressurised up to four atmospheres, thus affording the experimenter a welcome range in the Reynolds numbers available for the test. The flying model must, of course, be made, so far as is practicable, both geometrically and dynamically similar to the full-scale airplane represented ; to this end it is usually made of balsa wood and the correct weight and inertia factors obtained by the insertion of lead weights. In practice it is commonly found that models tend to recover from a spin rather more readily than do full-scale aircraft, so that the degree of control needs to be arranged with this factor in view.

The final chapter includes a description of the automatic controls intended to reduce the fatigue of the pilot on long flights, and of the principle of pilotless aircraft . with their ingenious gyroscopic mechanisms. In this description the author might fittingly have included a reference to the early pioneer work of Kettering in the U.S.A. and of Bygrave in Britain. It was, indeed, mainly due to the work of Bygrave's latter years, as leader of the instrument research team at Farnborough, that success was achieved in the design of the first " Queen Bee " as an anti-aircraft target capable of being controlled by ground radio both as to altitude and course flown. It may be hoped that the exercise of similar skill and ingenuity will provide the answer to the intricate problem set by the author, on page 236, where he emphasises the need for the discovery of some new principle for " irreversible control."

The book is well written and it has an attractive form ; both these qualities require care and time, and this explains, one may assume, why its preface bears so early a

date as 1950. Nevertheless, an odd misprint occurs, and, strangely enough, in the title : the use of the word " Aircraft " hardly prepares the reader for the entire exclusion of any discussion of autogiros or airships, or even of the increasingly familiar helicopter, in which stability factors are so critical.

We look forward to the issue of further books in this series.

Locomotive and Train Working in the Latter Part of the Nineteenth Century. Vol. 2. By E. L. AHRONS. Cambridge : W. Heffer and Sons, Ltd. Price 18s.

THE second volume of the reprint of the popular articles that appeared serially in *The Railway Magazine* deals with the English constituent companies of the former London, Midland and Scottish Railway. This volume reveals both the strength and weakness of the original articles. The London and North-Western Railway, for example, is dealt with rather sketchily, with no reference to freight engines, and stopping short before the introduction of the Webb four-cylinder compound passenger engines. The Midland articles, written when the series was an established success, are very comprehensive, though with this railway curiously enough Ahrons finds less material than usual over which to exercise his delightful sense of humour.

As a Bradford man one would naturally expect him to be well versed in the vagaries of the old Lancashire and Yorkshire. We are not disappointed ! His descriptions of train workings at Bradford Exchange Station, and of adventures between there and Sowerby Bridge can be read with a chuckle over and over again. " After one such journey to Sowerby Bridge," he writes, " I left the train there with the feelings of the golfer in the story, who had taken nineteen for the first hole, twenty-three for the second, and at the third ' began to get into difficulties.' From Sowerby Bridge I returned on my tracks and made for Halifax by the quickest and most direct route, viz., by walking over King Cross hill."

As a commentary upon train workings in the period 1875 to 1900, these essays could scarcely be bettered, and this second volume is no less finely produced than the first. A few of the illustrations are disappointing ; we feel sure that many better photographs of Aspinall's famous " Atlantic " exist that the heavily retouched official view of No. 1400 without its tender, but otherwise, as in the previous volume, the choice is generally admirable. We look forward to the completion of the remaining volumes of the series, which, while not attempting an exhaustive locomotive history, nor yet a full treatise on developments in design, will eventually present a full eye-witness account of one of the most colourful periods in British railway history.

Structural Analysis of the Dome of Discovery. By T. O. LAZARIDES. London : Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 25s.

THIS book stands in a class of its own, being a rather unusual compromise between a textbook and a report. It follows on a paper presented by G. Roberts in April, 1951, to the Institution of Civil Engineers, where the broad outlines of the design and Dr. Lazarides contribution to the design were discussed, but avoids repetition and concentrates on the details of the analysis.

It is comparatively seldom that a book is written with reference to a specific design and in general such books have rather a limited interest. In this case, however, owing to the unusual problems involved, in this highly redundant and complex structure, new methods of approach had to be developed, differing considerably from the standard textbook examples. It is felt, therefore, that this book should prove of considerable value to structural engineers concerned with the design of unusual structures and also should command the interest of other engineers accustomed to dealing with a few redundancies only, by showing that a problem involving around three hundred redundancies can be successfully tackled.

Relatively little comment is made in the book on the reason for and methods used in the original design. A reader interested in this should consult the paper previously mentioned. As indicated in the title, the problem treated is the analysis of the finished design, which, incidentally, was already constructed at the time of completion of this work. Due to the high degree of redundancy the problem was quite out of the reach of the usual strain energy methods, and the author rightly applied to it Southwells' relaxation method, which, in this case, is the only practicable line of approach. It is for the exposition of that method in a brief but clear manner and also for showing in detail how it can be applied to a complex structure that the book deserves praise. To date, beside Professor R. V. Southwell's original volume, little detailed information is available to the structural engineer on the use of relaxation, though one particular application, i.e., Hardy Cross moment distribution, has gained universal acceptance.

The derivation of expressions for " unit displacement " reactions deserves note, inasmuch as the structure consisted almost entirely of curved members. Treatment of lateral and torsional displacements is interesting, though the results are neglected in the final working. Worthy of note is the use of the method of superposition for dividing the unsymmetrical loading into symmetrical and skew symmetrical load systems thus reducing further work very considerably. As the author himself mentions, the nomenclature adopted and the methods of tabulation could have been improved, had the time been available.

The last part of the book—a discussion of the behaviour of the actual structure under load—is interesting, as it illustrates the great advantage of the relaxation approach over classical methods, namely, that at any stage of the analysis the designer can visualise exactly the deflections. The author very skilfully discusses the distribution of the load through the system and suggests means by which the design could have been improved. Looking at the results, one cannot but agree with the author that " . . . a structure of this type can only be analysed exactly or not at all ; approximate methods . . . may easily lead to very large and unknown errors." It is perhaps fortunate, in view of this, that the actual structure proved capable of standing up to the loads it had to carry without modification.

SHORT NOTICES

Marine Steam Engines and Turbines. By W. J. Fox and S. C. McBirnie. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 35s.—This book sets out to cover the requirements of those taking the Ministry of Transport examination for certificates of competency and of students whose knowledge of the subject is slight. For this purpose the volume is planned to accord a logical sequence to the principles and operation of reciprocating steam engines and turbines and the subject matter is presented in plain language and without recourse to higher mathematics. After briefly commenting upon engine-room procedure, reciprocating engines are discussed component by component, supplemented by notes upon bearings and lubrication. Valves and the various valve gears are extensively examined and the subject of indicator diagrams reviewed, followed by some short notes giving examples of emergency repairs. A short chapter upon the generation and properties of steam is followed by a consideration of three examples of compounding. Other subjects treated are ; the effects of clearance volume, the piston load, inertia force and torque of reciprocating engines and engine balancing. A number of special engines and turbines are individually described and the general design of condensers is reviewed. An extensive chapter is devoted to the question of multi-stage feed heating and various forms of closed feed systems and this is followed by a section in which steam turbines form the subject, the function and design of the various components being outlined together with questions related to expansion allowances, lubrication, safety devices and reduction gearing. The book concludes with an explanation of elementary steam turbine theory touching upon impulse and reaction blading, velocity diagrams, steam flow and the balancing of rotors. Line drawings, diagrams and photographs amplify the text, which includes a number of calculations to illustrate points discussed.

Woods Practical Guide to Fan Engineering. Edited by W. C. Osborne, B.Sc., and C. G. Turner. Colchester : Woods of Colchester, Ltd. Price 10s. 6d.—With its many years of experience in fan design and manufacture, few firms could be better qualified to compile and publish a book upon this subject than Woods of Colchester, Ltd. In his foreword to the book Mr. Geoffrey Woods points out that fans probably cover a wider range of sizes and types than can be found in any other machine, whilst the applications to which they are put are incredibly extensive. The publication of this practical guide to fan engineering was to a large extent prompted by the numerous instances the firm has encountered of the wrong use of fans, and the many problems involved in their correct selection and application in various parts of the world. The comprehensive nature of the information given in the book can best be shown by the following list of sections into which the subject matter is divided : Air Conditions for Human Well-being, Humidity, Ventilation Requirements, Air Motion, Ventilation Systems, Air Distribution, Fume and Dust Extraction, Air Cleaning, Evaporative Cooling, Airflow Measurement, Air Duct Design, System Resistance, Fans, Hazardous Applications and Arduous Conditions, Noise in Fan Systems, Selection of Fans, Back Draught Prevention, and Electric Motors for Fan Drives. Each section deals in a clear, concise manner with its subject and numerous drawings and diagrams supplement the text. The book concludes with a section containing useful data for fan designers and users. All concerned with fans and ventilation will find this an up-to-date reference work based on extensive practical experience and one well worth adding to their libraries.

Wood. D.S.I.R. London : H.M. Stationery Office. Price £1 1s.—*Wood* is Volume 8 of the selected Government reports, which deal with research carried out during the war under the direction of the Ministries of Supply and Aircraft Production. It contains twenty reports on the properties and working qualities of wood, most of which were prepared on behalf of the Ministries by the Forest Products Research Laboratory. The subjects covered include the microscopical investigation of failures in wood, the chemical factors involved in the use of wood with metals and the strength of such woods as American whitewood, Kara redwood, Sitka spruce, Western hemlock, and Douglas fir. A number of the reports deals with the laminating and bending of woods and one of them describes the dielectric heating of woods and glues. Many of the problems described are concerned with aircraft production, but the results can be applied to other woodworking processes.

B.B.C. Television Transmitting Stations

Two extensions of the B.B.C. television service are recorded this month. The high-power television transmitters at the Kirk o' Shotts television transmitting station are undergoing final tests preparatory to going into service on August 17th to replace the medium power transmitters which have been sending out the programme since March 14, 1952, as announced in our issue of that date. In addition the new Wenvoe station is being formally opened to-day, on medium power transmission. A brief description of the two stations is given here.

Kirk o' Shotts

THE station lies roughly midway between Glasgow and Edinburgh, on a site 900ft above sea level, where the 750ft mast brings the total height of the vision and sound aerials to over 1600ft, an important factor in securing the greatest possible service area, particularly in hilly country such as that lying to the north.

At Kirk o' Shotts the vision programme is received over the G.P.O. distribution network, which consists of a 1in tube coaxial cable system from London to Birmingham, a $\frac{3}{4}$in tube coaxial cable system between Birmingham and Manchester, and a radio-relay link between Manchester and Kirk o' Shotts. The Post Office radio receiving terminal at the station is housed in a separate building on the B.B.C. site and the video-frequency output from it is conveyed to the transmitting station by a short length of $\frac{3}{4}$in coaxial tube. The sound programme reaches Kirk o' Shotts over specially equalised G.P.O. telephone circuits similar to those used for other B.B.C. transmitting stations.

The vision transmitter, manufactured by Electric and Musical Industries, Ltd., is different from those installed at the earlier stations at Sutton Coldfield and Holme Moss, in that low level modulation is used. This change has not only enabled a considerable reduction to be made in the physical size of the transmitter but it offers increased overall efficiency with a consequent saving in power consumption.

Vision signals are fed to the modulation amplifier. This consists of, first, a three-stage d.c. input amplifier using receiver-type valves exclusively and having a cathode-follower output; secondly, a linearity correction amplifier, and, thirdly, a premodulation v.f. amplifier, also with a cathode-follower output, feeding the grids of the modulated amplifier. The black level is finally clamped at the input to the premodulation amplifier. The fact that this clamping has to be separated by a considerable number of stages from the transmitter output could introduce variations in the transmitted black level unless special precautions were taken. This possible difficulty is overcome by the inclusion of a black level r.f. feed-back circuit, which monitors the black level at the transmitter output and injects a suitable correcting signal into the vision circuits. A further advantage of this technique is that it tends to reduce any mains hum introduced by the Class "B" r.f. amplifiers forming the later stages.

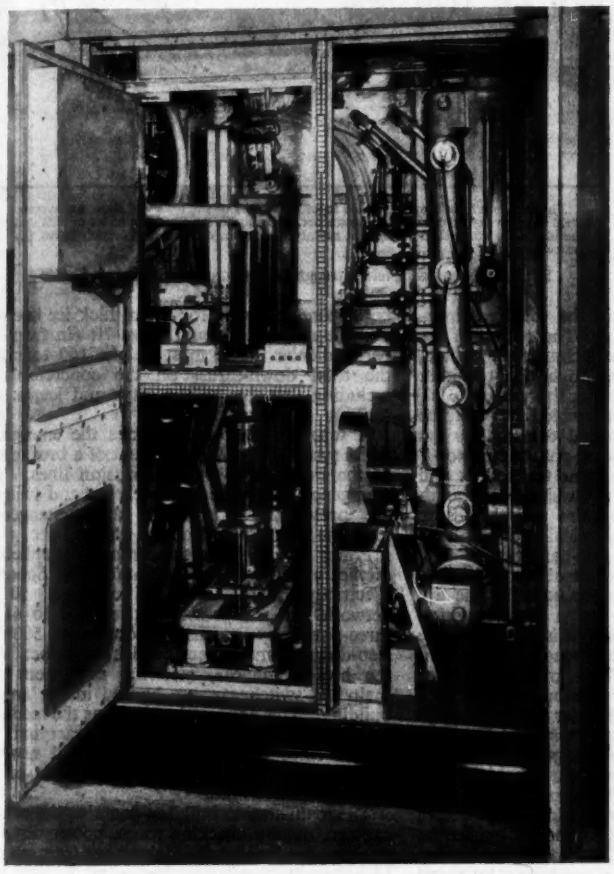


Fig. 1—Output Stage of High Power Vision Transmitter at Kirk o' Shotts

The modulation is applied to the grids of a pair of "ACT.27" air-cooled triodes, which operate as an earthed grid push-pull modulated amplifier having an output of approximately 600W peak white. This stage is preceded by a pre-modulation r.f. amplifier, a frequency multiplier and the crystal oscillator stage. The modulated amplifier output is fed to a chain consisting of three push-pull earthed-grid, Class "B" linear wide-band r.f. power amplifiers in series. The first employs a pair of "ACT.27" air-cooled triodes and produces an output of 3kW; the second is fitted with "ACT.26" air-cooled triodes and has an output of 12kW, whilst the third uses a pair of "BW.165" water-cooled triodes. A view of the output stage showing the water-cooled valves and output feeder is given in Fig. 1. The transmitter will be operated with an output power of 50kW.

From the outputs of the modulated amplifier, inter-stage couplings of the wide-band, three-stage, coupled-circuit type are used, and they are so tuned that their pass-band centre frequency is about 0·7 Mc/s below the carrier frequency. The two side bands are thus not symmetrical—the upper one being slightly attenuated—but a filter is used to obtain the final asymmetric side-band condition. A further three-stage coupled circuit is used at the anodes of the output amplifier and this is also arranged to change from a balanced to an unbalanced load to feed the coaxial output transmission line.

High-voltage d.c. supplies for the high-power stages are provided by oil-cooled metal rectifiers, one of the advantages of which is that the control circuits are simpler than those associated with the hot cathode mercury vapour type used in previous television transmitting stations.

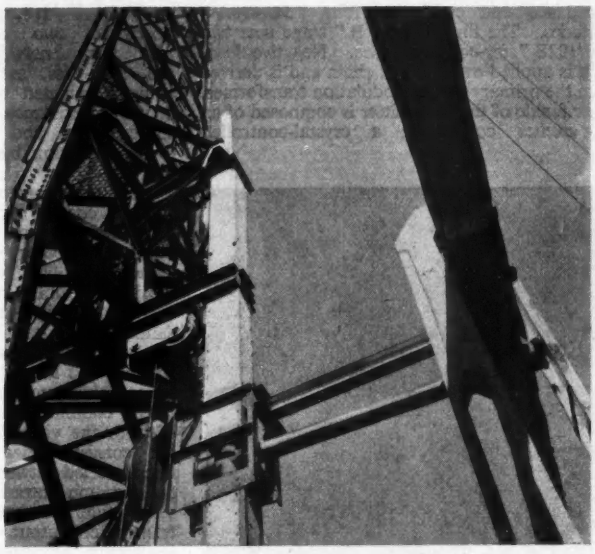


Fig. 2—Aerial Feeder Tensioning Mechanism

Air for cooling the valves in the earlier stages of the transmitter is drawn from outside the building, filtered and blown through the cooling ducts at the rate of 3000 cubic feet per minute. Two centrifugal blowers are used for this purpose, one delivering filtered air to the transmitter and the other exhausting it by suction. Thus, the air pressure in the cubicles is equalised and air leakage and noise are considerably reduced. Another improvement is that the design of the vision transmitter allows the air duct to be led in from below; the connecting ducts to the cooler room are therefore run under the floor. The blowers are driven by vee-belts at approximately 1000 r.p.m. and produce an air speed in the main ducts of between 1500ft and 2000ft per minute. An arrangement of dampers is incorporated in the system whereby the air, after leaving the valves, can either be exhausted to atmosphere, or circulated in the building for heating purposes.

Distilled water is used for cooling the valves in the final stage. Three tanks are provided, a main tank with a capacity of fifty gallons, a hundred-gallon reservoir tank and a fifteen-gallon expansion tank. The water is circulated by a centrifugal pump from the main water tank through a multi-tube radiator (where it is cooled by air from a separate air-blower), to the valve jackets in the transmitter, and back to the main tank. Except for the air-blown radiator, the components are mounted together to form a self-contained unit. No ferrous metal is used

in the construction of the water-cooling system, which operates on a closed circuit to exclude air. Water expansion is taken up by the fifteen-gallon expansion tank, in which the space above water level is filled with nitrogen at a pressure of approximately 5 lb per square inch above atmosphere. The normal water flow for a pair of "BW.165" valves is eighteen gallons per minute and the flow in the system is electrically metered. Contacts are provided in the main interlock circuit, to ensure that the transmitter cannot be powered until the water flow is correct, and, conversely, that a failure of the water-cooling system will close down the transmitter.

The high-power sound transmitter, manufactured by Standard Telephones and Cables, Ltd., is a conventional high-power, Class "B" modulated equipment. Modulation is applied at the anodes of both the penultimate and the final r.f. stages. The transmitter uses air-cooled valves throughout and has a carrier output of 18kW at 100 per cent modulation. There are five push-pull stages in the a.f. chain, the first two using "4074A" double triodes; the third is a Class "A" stage and uses a pair of "5C/450A" pentodes. Next there is a cathode-follower-driven stage having a low output impedance and employing four "5C/450A" pentodes. The final Class "B" stage uses two "3J/192E" air-cooled triodes. Negative feedback is applied over the a.f. chain and is derived from the primary of the modulation transformer. The r.f. side of the transmitter is composed of an r.f. exciter comprising a crystal-controlled

Fig. 3—Radio Link Terminal and Aerial Masts at Kirk o' Shotts

oscillator followed by a buffer stage, two stages of frequency trebling and an output amplifier. The first stage of the transmitter proper uses a single "4H/180E" air-cooled tetrode, while the penultimate and final amplifiers embody a single "3J/261E" blast-cooled triode each. Variable inductive coupling is used between stages. The filaments of the three r.f. power amplifiers and the Class "B" modulator valves are supplied with heating current from metal rectifiers equipped with current-limiting reactances to control the current supplied to the filaments when starting. The remaining valve filaments are a.c. heated. The main high-tension supply is derived from a 6kV, three-phase, full-wave bridge-connected rectifier, which is a grid-controlled, hot cathode, mercury vapour unit. A half-voltage, half-wave output is taken between the star point and negative to supply the first earthed-grid r.f. amplifier and the a.f. driver stages. The equipment is grid-controlled, giving high-speed overload protection, together with automatic restoration of voltage and smooth increase of output voltage from zero on starting, as well as a substantially constant output voltage between plain carrier and fully modulated conditions.

The main blower of the air cooling system provides 3300 cubic feet per minute to the base of the power amplifiers. Discharge air is drawn from the tops of the transmitter cabinets by a smaller exhaust blower. All the power equipment is housed in a separate enclosure, one compartment of which contains the power supply and distribution control contactors and protective circuits, whilst the other accommodates the high-tension rectifier and main modulation equipment.

The output of the vision transmitter is passed to the vestigial side-band filter, which consists of a constant-resistance "transmission line" filter. It is composed of two complementary networks, the high-pass section being terminated by a constant resistance absorber load and the low-pass section by the aerial system.

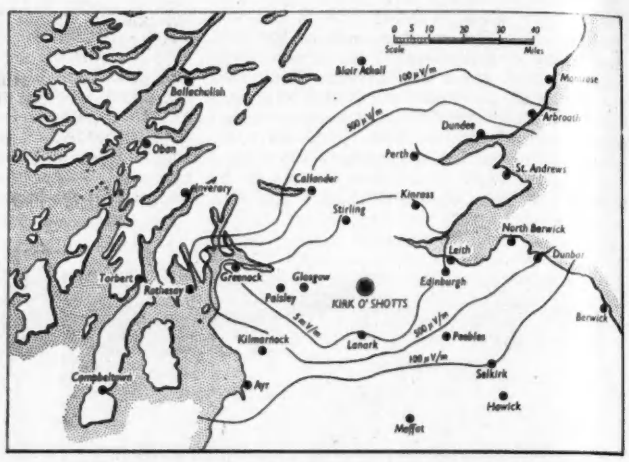
The filter is constructed from coaxial copper tube transmission line having an outer diameter of 5in, but with the diameter of the inner conductor varied to obtain the required impedance for the various stubs. The output of the low-pass section is taken to a changeover switch, enabling the shaped output to be fed to either the combining unit and aerial or the test load.

The combining unit into which the outputs of both the vision and sound transmitters are fed consists of a "sound-pass/vision-stop" filter inserted between the sound transmitter and the common output, and a "vision-pass/sound-stop" filter between this point and the vision transmitter output. Mechanically these filters are similar to the vestigial side-band filter.

From the output of the combining unit the signals are fed to the common aerial at the top of the 750ft mast. A new design of transmission line is used for this purpose. It is a coaxial tube having an outer conductor made from a 5in diameter copper tube. The inner conductor, however, is not a copper tube but consists of a locked coil wire rope, the outer layer of which is composed of wires made from high conductivity copper. This rope, together with the outer tube, is suspended pendulum fashion from the top of the mast. The wire rope is connected at the base of the mast to a loading mechanism (Fig. 2), which is arranged to apply a tensioning force of approximately 2 tons. It is located coaxially within the outer conductor by small rod insulators, spaced at 120 deg., projecting from the inner surface of the tube at suitable intervals.

By suspending and loading the transmission line in this way the electrical uniformity tends to increase towards the upper end, thereby reducing the formation of echoes, which have the greatest time-delay when the irregularities producing them are at the greatest distance from the transmitter.

The mast (Fig. 3), built to B.B.C. detail specification of structural requirements by British Insulated Callender's Construction Company, Ltd., is generally similar to those already in use at Sutton Coldfield and Holme Moss. The supporting lattice-steel mast is 600ft high and is triangular in section, each face being 9ft across. This is surmounted by a cylindrical section, 112ft high, having slots cut in its surface, which could form a v.h.f. aerial for sound broadcasting if required. Surmounting the cylindrical section is a 35ft steel tower carrying the combined sound and vision aerials. They consist of two tiers of four vertical dipoles, each fitted with an electric heater, controlled from ground, to prevent the formation of ice, which would upset their characteristics. The structure is stayed at four levels by sets of three locked coil steel wire ropes spaced equidistantly around the mast and ranging in circumference from 4¾in to 6in. All stays together weigh over 21 tons, and have breaking loads up to 210 tons. The design provides for wind velocities ranging from 80 miles an hour at the base to a 120 miles an hour at the top. Under these conditions the total wind load would be 80 tons, allowing for a ½in thick ice coating, and the masthead would move 7ft 6in from the perpendicular. The mast weighs 140 tons and the total down-thrust on the concrete base, including that due to the stays and ice, is 336 tons.



The contours have been calculated from the results of site tests and show the average field strength expected from the transmitter. Owing to the screening effect of hills and buildings the actual field strength at any given place may differ considerably from the value indicated.

Fig. 4—Estimated Field Strength Contours from Kirk o' Shotts

A separate 150ft mast carries the emergency aerial system for use in the event of a breakdown of the main aerial or transmission lines. The emergency aerials are separately fed and switches are provided to facilitate rapid changeover from the main to the standby system.

Power for operating the station is supplied by duplicate feeders from the South West Scotland Electricity Board's 11kV, three-phase, 50 c/s network and the pressure is reduced to 415V, three-phase by means of duplicate 500kVA step-down transformers, which, together with the h.v. switchgear, metering equipment and main l.v. switchgear, are housed in the annexe building. This annexe also contains the medium-power transmitters which, after carrying the service since the station opened, will now be held in reserve in case of a breakdown of the high-power transmitters.

The main station building contains the offices, canteen, quality checking room, power distribution switch gear and the high-power transmitters. It is broadly similar in design to the previous stations at Sutton Coldfield and Holme Moss; the walls are built of local Scottish brick relieved with artificial stone dressings to harmonise with the surroundings, while the roof is flat and finished with a special roofing felt covered with tarmacadam. External doors and window-frames are of metal, whilst all internal doors are flush-panelled in the interest of cleanliness. The station is connected with the public water supply but is provided with its own drainage system.

The accompanying map (Fig. 4) shows the estimated field-strength contours for the 50kW high-power transmitter, and serves as a rough guide to reception conditions in the area, subject to local variations. Reception is usually possible at a field strength as low as 100 microvolts per metre, but depends on the degree of local interference, especially that produced by motor-cars.

PRINCIPAL CONTRACTORS

Plant—High-power vision transmitter, Electric and Musical Industries, Ltd.; High-power sound transmitter, Standard Telephones and Cables, Ltd.; medium

power vision and sound transmitters, Marconi's Wireless Telegraph Company, Ltd. ; aerials and medium-power vision and sound transmitter combining filter unit, Marconi's Wireless Telegraph Company, Ltd. ; main transmission lines and high-power vision and sound combining filter, Electric and Musical Industries Research Laboratories, Ltd. ; main low-voltage switchgear, Brush Electrical Engineering Company, Ltd. ; 11kV/415V transformers, English Electric Company, Ltd. ; high-voltage switchgear, Switchgear and Cowans, Ltd. ; auxiliary low-voltage switchgear, Standard Telephones and Cables, Ltd. ; emergency lighting battery, Alton Battery Company, Ltd. ; valve cooling and ventilation, Rosser and Russell, Ltd. ; coaxial cable to reserve aerials, Telegraph Construction and Maintenance Company, Ltd. ; " Thermovent " heating, E. K. Cole.

Civil Engineering and Buildings—Masts (750ft and 150ft), British Insulated Callender's Construction Company, Ltd. ; roads and buildings, M'Lean and Co., Ltd.

Programme Links.—The G.P.O. and their contractors were responsible for the provision of the radio link from Manchester and the associated control equipment.

Wenvoe Transmitting Station

Regular programme transmissions from the B.B.C.'s new television station at Wenvoe are due to begin to-day and will be radiated by the medium-power sound and vision transmitters using the main mast and aerial system. This medium-power service will continue until the high-power transmitters, which are at present under construction, have been completed.

The new station is built on a site of approximately thirty acres, close to the Cardiff/Swansea Road, some 5 miles to the west of Cardiff. It is 400ft above sea-level and the transmitting aerials are on the top of a 750ft mast, which brings the total height to over 1100ft.

Vision transmission will be on a frequency of 66·75 Mc/s (4·495m) and sound transmission on 63·25 Mc/s (4·745m). The medium-power transmitters, built to B.B.C. specification by Marconi's Wireless Telegraph Company, Ltd., will ultimately be held in reserve in case of a breakdown of the high-power transmitters. They are housed in the annexe building and form a completely separate installation.

The medium-power vision transmitter is a low-level modulated equipment with a " peak white " output power of 5kW. Modulation is carried out at the 500W level and the signals are then amplified by two Class " B " wide-band linear r.f. amplifiers, each using a pair of English Electric " BR.191 " forced-air-cooled triodes. The appropriate shaping of vestigial side-band signals radiated by the vision transmitter is carried out in its own circuits, and not by a separate vestigial side-band filter as will be the case in the high-power transmitter. The valve filaments are a.c. heated, with the exception of those in the modulated amplifier and the linear amplifiers, which derive their supply from metal rectifiers. Transmitter h.v. supplies are obtained from hot cathode mercury vapour rectifiers, which provide a maximum of 3kV for the anodes of the linear Class " B " amplifier stages.

The sound transmitter has an output power of 2kW and is a conventional Class " B " modulated unit. All valve filaments are a.c. heated. As in the case of the vision transmitter, the crystal controlled drive and the power conversion equipment are built as an integral part of the transmitter.

Both transmitters are contained in similar sheet steel cubicles mounted side by side and so present a single continuous front in the transmitter hall. Part of the transmitter cubicles can be seen in the background of Fig. 5.

The air blast cooling equipment and combining filter are mounted behind the transmitter cubicles, which are built into a sound-proof partition wall, so as to isolate the noise of the air blowers from the control desk situated immediately in front of the transmitters (Fig. 5).

Both transmitters are controlled and monitored from this desk, which incorporates a built-in waveform monitor and two picture monitors in addition to the conventional controls and meters. The provision of the two picture monitors enables the incoming signals to be compared with those radiated. Programme switching for both sound and vision circuits is accomplished at the desk. The controls of each transmitter are sequence-interlocked to ensure that the various supplies are applied in the correct order and, where necessary, with the appropriate time interval between each. Near the control desk are the vision and sound programme input equipment bays and the test waveform generating equipment, which provides a variety of signals for testing, lining up and maintaining the characteristics and performance of the vision transmitter.

Wenvoe station will ultimately receive its vision programmes over a coaxial cable from London via Bristol and Cardiff, which is rented from the G.P.O. as part of the national distribution system for television. Until this cable is completed programmes will leave London on a cable circuit as far as the G.P.O. research station at Dollis Hill. From there to Cardiff they will travel over an experimental radio link installed by the Post Office, completing the journey to Wenvoe by cable. The sound programme will reach Wenvoe over specially equalised G.P.O. telephone circuits similar to those used for other B.B.C. transmitting stations.

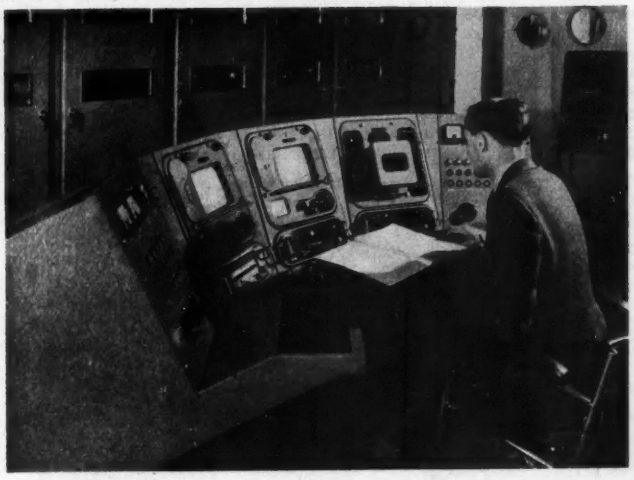


Fig. 5—Control Desk for Medium Power Transmitters at Wenvoe

The mast carries an aerial system designed to accept the full power from the main transmitters, both mast and aerial system being generally similar to those already in use at Sutton Coldfield, Holme Moss and Kirk o' Shotts. The supporting lattice-steel mast is 600ft high and is triangular in section, each face being 9ft across. This is surmounted by a cylindrical section, 110ft high, having slots cut in its surface, which may eventually form a v.h.f. aerial for sound broadcasting. Surmounting the cylindrical section is a 40ft steel tower carrying the combined sound and vision aerial. This consists of two tiers of four vertical dipoles each fitted with an electric heater, controlled from the ground, to prevent the formation of ice on the dipoles, which would upset their characteristics. The structure is stayed at four levels by sets of three locked coil steel wire ropes spaced equidistantly around the mast. The stays range in circumference from 4¾in to 6in.

A separate 150ft mast carries the emergency aerial system for use in the event of a breakdown of the main aerial or transmission lines. The emergency aerials are separately fed and switches are provided to enable a rapid changeover to be made from the main to the standby system.

As at Holme Moss and Kirk o' Shotts, the outputs of the Wenvoe vision and sound transmitters are combined at ground level and a single transmission line is used to convey this combined output to the common aerial system at the top of the mast. The transmission line is similar to the one at Kirk o' Shotts, described above, which was developed and built for the B.B.C. by Electric and Musical Industries, Ltd.

Power for operating the station is taken from the South Wales Electricity Board's system. Duplicate 500kVA transformers fed from a 6·6kV feeder provide a supply of 415V, three-phase, 50 c/s. In addition, a 240V single-phase standby supply is available to provide mast lighting and other essential services if the e.h.v. feeder has to be disconnected for maintenance purposes. The h.v. switchgear, metering equipment and main l.v. switchgear are in the annexe building, the transformers being mounted on an adjacent raft.

The main station building contains the offices, canteen, quality checking room, power distribution switchgear and the accommodation for the high-power transmitters, the installation of which is now proceeding. It is broadly similar in design to the previous stations ; the walls are of local brick relieved with Portland stone dressings, while the roof is flat, finished with asphalt. External window-frames and doors are of metal, with the exception of the main entrance doors, which are of panelled hardwood. All internal doors are flush panelled in the interests of cleanliness. The station is connected with the public water supply but is provided with its own drainage system.

The medium-power transmitters should provide satisfactory service over a considerable area of South Wales and South-West England, including Cardiff and Bristol ; but reception will, of course, be more liable to interference, particularly in fringe areas, than when the high-power transmitters come into service.

Principal Contractors

Plant.—5kW vision transmitter and 2kW sound transmitter, Marconi's Wireless Telegraph Company, Ltd. ; main aerial, Marconi's Wireless Telegraph Company, Ltd. ; main transmission lines, Electric and Musical Industries Research Laboratories, Ltd. ; main low-voltage switchgear, Brush Electrical Engineering Company, Ltd. ; emergency lighting battery, The Hart Accumulator Company ; valve cooling and ventilation, Rosser and Russell, Ltd. ; coaxial cable to reserve aerials, Telegraph Construction and Maintenance Company, Ltd.

(The high-power vision and sound transmitters, the installation of which has not yet been completed, were designed and manufactured by Electric and Musical Industries, Ltd., and Standard Telephones and Cables, Ltd., respectively.)

Civil Engineering and Buildings.—Masts (750ft and 150ft), British Insulated Callender's Construction Company, Ltd. ; roads and buildings, Gee, Walker and Slater, Ltd.

Programme Links.—The G.P.O. was responsible for the provision of the programme link and the associated control equipment.

Naval Architects' Autumn Meeting

At the invitation of the Associazione Italiana di Tecnica Navale, the Institution of Naval Architects is holding a joint autumn meeting in Italy, which will open in Genoa on Thursday, September 25th, and the following is the programme as arranged at present.

At Genoa, five papers will be read on Friday, September 26th, two in the morning, namely " Longitudinal Strength—A Review of Some Recent Developments," by James Turnbull, O.B.E., and " Six Recent Atlantic Liners," by Lieut.-General E. de Vito and three in the afternoon, " Ship Model Correlation," by Professor E. V. Telfer, D.Sc., Ph.D., " Measurement of Vibrations," by Dr. Ing. G. Villa, and " Fire Protection in Passenger Ships," by J. Venus and E. C. B. Corlett, M.A., Ph.D.

The meeting will be continued in Rome, where three papers will be read in the forenoon of Monday, September 29th, under the following titles : " Effect of Pitch and Blade Width on Propeller Performance," by R. W. L. Gawn, O.B.E., R.C.N.C., " Principal Characteristics of Warship Design," by Dr. Ing. Professor A. Servello, and " An Investigation into the Motions of Ships at Sea," by A. J. Williams, R.C.N.C.

During the meeting there will be official receptions in Genoa, Rome and Naples, and visits and excursions of both technical and topical interest.

Flour Mill Conveying System

FOR flour mill pneumatic conveying systems it has been the accepted practice to employ centrifugal fans because, although it was known that the use of axial flow units would effect a considerable increase in efficiency, the high air pressures required for the conveyance of mill stocks would have called for the production of special and expensive designs. To obtain the necessary pressures high-speed impellers would be required and these would cause the noise to rise to an objectionable level. Another difficulty was that the motors available were, in the main, unsuitable, since axial flow fans, when handling heavily dust-laden air, require flameproof motors of suitable size and shape to satisfy the aerodynamic requirements of the fan.

The fan problems have been studied by Woods of Colchester, Ltd., and solved by the introduction of high-pressure contra-rotating Aerofoil fans. Henry Simon, Ltd., has carried out research work with these fans as part of a conveyor system at the company's experimental mill at Cheadle Heath, Stockport, and as a result has installed an axial flow system at the Hovis Mill, Westminster, which we illustrate. By fitting multi-stage Aerofoil fans in place of centrifugal fans, power consumption has been reduced materially and an increased degree of flexibility of operation has been attained in addition to a saving in space.

The Westminster mill has a capacity of thirty-three sacks an hour, equivalent to 132 tons a day, and the pneumatic conveying system which has seventy-five lifts is divided into three separate sections in order to ensure economy in power consumption. Each section is equipped with a five-stage Aerofoil unit and the flexibility of the arrangement is illustrated by a five-stage fan having two stages situated on one side of a 90 deg. bend and the remaining three stages on the other. The fifth stage, which normally is switched off and idled with a consequent saving in running cost, is used for boosting the pressure during the starting-up period or during power cuts. The three multi-stage fan units, which can scarcely be heard above the background sound level of the mill, require a total of 38 h.p., being 21 h.p. less than that required for a comparative centrifugal fan installation and representing a saving of 35·6 per cent in power.

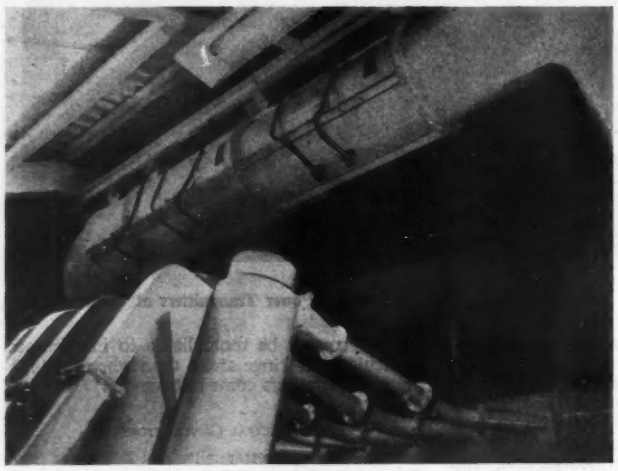
The contra-rotating Aerofoil fan consists of two impellers in a single cylindrical casing, and driven in opposite directions by independent Buxton-tested flameproof squirrel-cage motors developed by Woods of Colchester, Ltd. The motors are identical and interchangeable, and the separate drive for each impeller reduces the risk of a complete fan shut-down to a minimum, since a motor failure means only the temporary loss of one stage.

Since fan pressure varies as the square of the air velocity over its blades, a contra-rotating fan produces about three times the pressure of a single-stage, non-guide-vane fan, or more than twice that of a downstream guide-vane fan unit, without a proportionate increase in noise. A static pressure of 7in water gauge can be obtained with one standard contra-rotating fan having a tip speed of only 14,000ft per minute. Two or more contra-rotating fans can be bolted end to end to form a multi-stage unit to produce a pressure equal to the sum of the individual fan pressures, this being possible because the air enters and leaves a contra-rotating unit on an axial path, rotation occurring only between the two impellers.

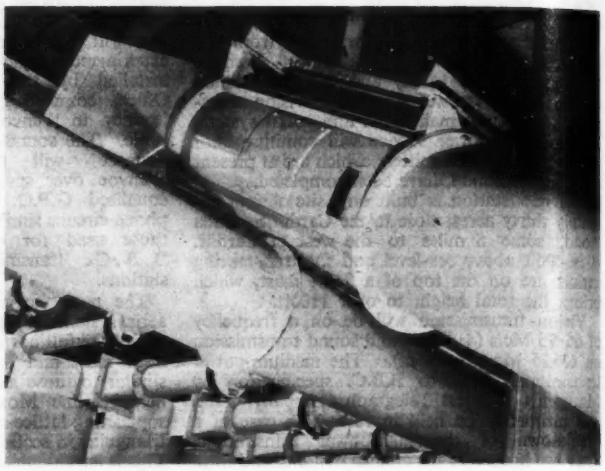
Multi-stage working, apart from enabling high pressures to be obtained economically, permits flexibility in the capacity of pneumatic conveying systems, an increase being obtained by adding another contra-rotating unit. A simple form of regulation is inherent in the system, in that the volume handled by a two-stage contra-rotating fan can be reduced by one-third and the power input by 60 per cent by switching off and idling the first stage impeller.

With different motor combinations it is possible to regulate the volume of a four-stage unit down to 50 per cent in five steps with a corresponding drop in power input down to 20 per cent. Apart from the range of volume control this new system is more efficient than any form of regulation available hitherto, due partly to the low idling loss, but more especially to the fact that volume is reduced by switching motors off while the remaining motors continue to run on full load. The Aerofoil fan can be inserted into the run of ducting without the bends which centrifugal fans necessitate, so that losses in the system are reduced to a minimum.

One of the requirements in conveying flour and mill stocks is a fine surface finish to the fan blades, and this condition is satisfied by the Aerofoil impeller, which is die-cast from silicon-aluminium alloy in polished steel moulds. The efficiency of the Aerofoil fan is said to be 30 per cent to 40 per cent higher than that of many of its centrifugal counterparts, and the overall efficiency exceeds 70 per cent over a wide range of duties.



Five Stage Fans in System



Two Stages of Five Stage Fan Assembly

Multi-stage Fans in System

Passenger Liner "El Djezair"

THE Forges et Chantiers de la Mediterranee has recently completed at its La Seyne shipyard for the Compagnie de Navigation Mixte the passenger liner "El Djezair." This ship, which attained a maximum speed on trial of 23·25 knots, has been designed for the company's service between Marseilles and Algerian ports, and completely breaks away from tradition, being unusual, in that the machinery has been placed well aft. This arrangement has been advocated in many quarters in recent years, and its adoption by the French company may give the lead to future design.

The hull, which has been built under the survey of the Bureau Veritas, is mainly welded, and the decks, bulkheads and double bottom, which have been prefabricated, are entirely welded. Our illustration shows the raked stem, cruiser stern, the raked bridge front, the long sweep of the superstructures and the unusual profile occasioned by placing the funnel and machinery aft. Three decks designated "A," "B" and "C" extend for the whole length of the ship, and there is an orlop deck forward of the engine-room, while three decks "D," "E" and "F" form the superstructures and extend for three-quarters of the length of the ship. Many passenger ships built on the Continent make extensive use of aluminium alloys, and to increase deadweight light alloys have been widely employed in the construction of the superstructures of "El Djezair." The three holds, one of which is refrigerated, are forward of the machinery spaces and have a capacity of 4100 cubic metres with 932 cubic metres of refrigerated space. No. 1 hold is divided into wine tanks, and two of the cargo 'tween decks are fitted out so as to provide accommodation for enlisted men when required, while other 'tween decks are equipped

for the storage of motor cars and, in one instance, horses.

The main particulars are :

Length between perpendiculars	413ft 9in
Breadth moulded	59ft 5in
Depth moulded to upper deck (" B ")	28ft 6in
Loaded draught	21ft 8in
Deadweight	2175 tons
Displacement	7102 tons
Gross tonnage, about	9100
Service speed	20·5 knots
Normal power	12,000 s.h.p.

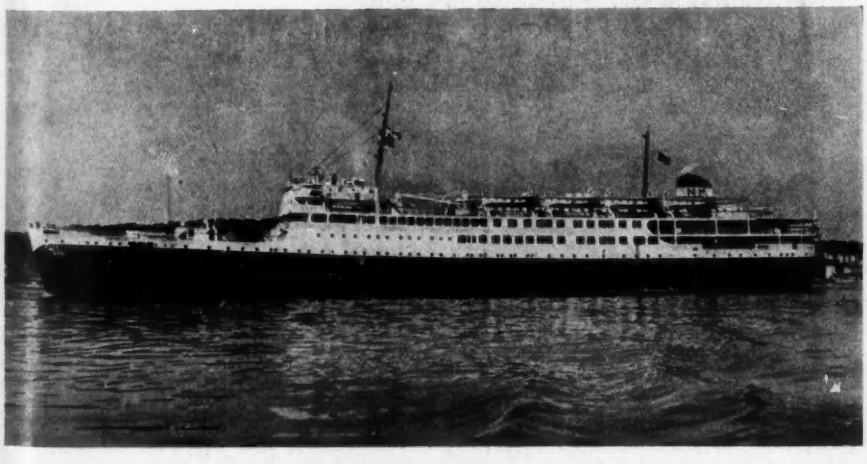
A total of eighty-four first-class and 246 second-class passengers are carried, and there is space for 1200 deck passengers. The first-class passengers are accommodated in cabins forward on the promenade deck " D " and on " C " deck, including two de luxe cabins and a number with private bath rooms, and the public rooms, together with the dining saloon, are situated on the same deck aft. The cabins for the second-class passengers are on " C " and " B " decks ; there is a smoking room on " C " deck and a dining saloon which extends for the full width of the ship on " B " deck. A crew numbering 111 is carried and the officers have their quarters in a house on the boat deck (" E "), while the remainder are accommodated aft on " B " deck and also to port and starboard of the engine and boiler casings on " A " deck.

All the ten lifeboats, including the whaler and service boat, are of light alloy, and the holds are served by four electric cranes of 3 tons capacity, and four continuous service elevators specially designed for the quick loading and unloading of mutton carcases, fresh fruit and vegetables. Other equipment includes hydraulic-electric steering gear and automatic detection and fire-extinguishing arrangements, while the refrigerated spaces are served by four Quiri ammonia machines, three of 64,000 frigories per hour for the holds and one of 9400 frigories per hour for the ship's store rooms.

Machinery

As already mentioned, the machinery spaces are placed right aft, with the boiler-room built over the shaft tunnel and the engine-room situated further forward. The ship is propelled by two sets of single-reduction geared Parsons turbines, which develop a total of 12,000 s.h.p. to give the ship a service speed of 20·5 knots when driving two four-bladed propellers of 13ft 6in diameter at 180 r.p.m. Steam is supplied by two oil-fired water-tube Alsthom-La Mont boilers at a pressure of 370 lb per square inch at a temperature of 700 deg. Fah. The relatively low steam pressure is because the turbines were built for a ship of the same name which was sunk in 1944, and when salvaged, after the war, the machinery was found to be in good order and so was installed in the new " El Djezair." The waste gases from the boilers are lead through uptakes to a funnel of Valensi-F.C.M. " Strombos " design, which ensures that soot and grit do not fall on the decks.

The auxiliary machinery includes two electrically driven bilge and ballast pumps, each rated at 150 tons per hour, and a submersible pump with a capacity of 85 tons per hour in the boiler-room. For the various other ship services four 50 tons per hour pumps are supplied and there are two pumps of 25 tons per hour capacity, one for the fresh and one for the hot water systems, with the addition of special pumps for handling wine. To supply the electrical power required by the motors of the engine-room pumps, steering gear, deck machinery, domestic services and lighting, two 400kW turbo-generators have been supplied, together with four diesel generators, two of 330kW, one of 80kW, and one of 30kW. An a.c. lighting system has been adopted and current is supplied at 42V and 50 cycles per second.



Passenger Liner " El Djezair "

Streamlining Production of I.C. Engines*

IT is a little over two years since the report of the Internal Combustion Engine Productivity Team was published and something over two and a half years since its visit to the United States. The industry has in that time assimilated what the team had to say and many companies have incorporated the recommendations of the report in policies of expansion which were already under way. Internal combustion engine production, especially production of diesel engines, has expanded since 1932, and markedly since the war ; in fact, some companies have expanded their outputs almost phenomenally in the post-war years. The team's visit came in the middle of this period of rapid expansion and, though it has been of material assistance to a large number of companies, the effect of the report was to add momentum to changes already taking place rather than to initiate new developments. The industry is now stabilising itself after its rapid expansion and fitting itself to meet increasing competition from Germany and other countries.

It is impossible to arrive at any figure of overall productivity in the industry. Moreover, figures of one company are often calculated on bases completely different from those of another and are thus not comparable. Comparative measurement of productivity has been found statistically difficult in most industries. In the internal combustion engine industry there is no unit to measure comparative output that is completely free from statistical objection. Value and quantity are often meaningless as measures of output ; brake horsepower units, though sometimes misleading are frequently taken as units of output for the industry. The main objection to brake horsepower as a measure of output is that a change in engine design could speed the engine up and increase its brake horsepower without any increase in physical output. Figures either of quantity or b.h.p. which are quoted below have been provided by the companies concerned and are quoted because, in spite of possible statistical objections, they do give an indication of the importance of the changes that have been made in recent years in the industry.

A number of companies report increases in both output and productivity during the last few years. British Polar Engines, Ltd., has doubled production in the last five years with little increase in the labour force ; Crossley Brothers, Ltd., has trebled its output since 1947 with a comparatively small increase in personnel ; Davey, Paxman and Co., Ltd., has in the last few years more than doubled its output of certain major engine components formerly made by specialist suppliers ; Mirrlees, Bickerton and Day, Ltd., has increased its output, measured in b.h.p., from 50,000 b.h.p. in 1946, to 210,000 b.h.p. in 1950, while total manpower was not quite doubled ; the National Gas and Oil Engine Company has increased its output measured in b.h.p., from 60,000 b.h.p. in 1947 to 200,000 b.h.p. in 1951, with an increase in total manpower of nearly 60 per cent ; F. Perkins, Ltd., has increased its output, measured in b.h.p., from 229,000 b.h.p. in 1946 to 2,125,000 b.h.p. in 1951 ; Petters, Ltd., has expanded its output of cylinders from 800 a week in 1948 to 2000 now, without any equivalent increase in manpower ; Ruston and Hornsby, Ltd., with a small percentage increase in personnel, has more than doubled its output since 1947.

Many companies in the industry are in the middle of reorganisation, which is likely to increase their efficiency still further. With continued world-wide mechanisation of agriculture, with the expanded use of diesel locomotives and the increased use of diesel engines as power units, there seems every prospect of continued expansion in the size of the world market. The competitive power of the industry has been greatly strengthened in the course of the post-war years and this increased strength is likely to make it possible for the industry to ensure for itself a good share of the world market in coming years. The productivity team can claim no more than to have been of assistance in the process of rationalisation in the industry. It pointed out some weaknesses that affected the whole industry, such as the inadequate supply of machine tools and the insufficient capacity in this country for forging and machining of solid-forged crankshafts ; on both these matters the British Internal Combustion Engine Manufacturers' Association has done its best to improve matters by factual investigation and report and by discussions with Government departments and the associations of the other industries concerned.

The main value of the team's report, like that of others, lay in its critical analysis of the factors making for high productivity in individual American companies, thus augmenting what was already known as a result of private visits to America from this country. In general, simplification of the range of products is the basic characteristic of American industry making for high productivity. In the British internal combustion engine industry the ranges of engines produced in any one factory were already being limited by many companies long before the team's visit, and this policy continues. For example, Blackstone and Co., Ltd., has reduced the number of horizontal types produced from twenty-two to six since 1936 ; Davey, Paxman and Co., Ltd., has cut down the number of models produced from twenty-two to four since 1948 ; the National Gas and Oil Engine Company has cut its range from thirty to fourteen models of engines since the war ; R. A. Lister and Co., Ltd., has in recent years limited its range to three main types of engine instead of twelve, and one of its subsidiary companies is concentrating on one model only ; Mirrlees, Bicker-

* Anglo-American Council on Productivity : " Follow-up " Report on the Report of the I.C. Engine Productivity Team. Summary.

ton and Day, Ltd., is now concentrating on two main models, which have been designed and brought into production since 1946; Petters, Ltd., has since 1948 concentrated on two main models of both diesel and petrol engines; Ruston and Hornsby, Ltd., plans to manufacture basically standard engines to which non-standard parts can be added as required; whereas some other companies, such as F. Perkins, Ltd., and Stuart Turner, Ltd., have always specialised within narrow limits. The advantages of range simplification had probably already been learnt before the productivity team's visit, but its American experience served to underline them.

Where the team's report may have had more specific influence is in encouraging the streamlining of production by reorganisation of factory layout and, often, production methods. All the more important companies in the industry have either concluded a process of reorganisation or are in the middle of it. The achievement of a flow-line of production is, of course, not unrelated to the simplification of the range of production; this is exemplified by R. A. Lister and Co., Ltd., which as well as limiting the range of engines produced has opened a number of new sub-factories, each of which concentrates on one type of production. In this manner the company has reorganised its production to achieve a flow of work through each factory. F. Perkins, Ltd., is extending and reorganising its factory. Mirrlees, Bickerton and Day, Ltd., has established machine lines for the machining of camshafts, cylinder liners and crankshafts; the machined parts are sub-assembled and sub-assemblies are fed to the sides of the main assembly line. Davey, Paxman and Co., Ltd., in the process of rationalisation of its engine production, is changing over from small to large-batch production and is specialising its processes of manufacture. British Polar Engines, Ltd., like many other companies, has extensively re-equipped the machine-shops with new machine tools. W. H. Allen, Sons and Co., Ltd., has undertaken a comprehensive scheme of machinery replacement since the war.

Assembly shops have, and are being, reorganised with the same object. Most companies making smaller and medium-sized engines are assembling them on conveyors. The National Gas and Oil Engine Company has developed a flow-line for the "KB" and "PB" engines for the production of which an assembly roller conveyor runs direct to the test shop; the fitters are supplied on one side of the conveyor from material feeding trays. Ruston and Hornsby, Ltd., is in process of splitting up the assembly of the medium-sized engines into stages on the assembly line; by the side of the main assembly line sub-assembly is carried out of parts such as cylinder heads. At Petters, Ltd., there are two main assembly lines, one for petrol and one for diesel engines.

In the attempt to achieve a flow-line of production greater attention has been paid to methods of handling. Apart from the extended use of conveyors and lift trucks, tilt racks on trolleys have been found valuable to move parts such as connecting-rods around the shop. Davey, Paxman and Co., Ltd., uses radio communication between the transport office, lift trucks, cranes and other vehicles; R. A. Lister and Co., Ltd., has paid special attention to the use of compressed air for jigs and lifting equipment; Mirrlees, Bickerton and Day, Ltd., has installed a number of jib cranes along the assembly line; F. Perkins, Ltd., has adopted palletised unit handling by fork lift trucks. The practice is spreading of having a specialist to look after handling problems.

A number of companies, like the Turner Manufacturing Company, Ltd., have given more attention to methods of production planning and control.

The need for the extension of work study in the industry has been accepted by many managements and work-study is increasingly being adopted in the industry, but one or two companies have encountered difficulties with their rank and file employees when attempts have been made to introduce it. Consideration has been widely given to payment under incentive bonus schemes in addition to piece-work payment, which is the basic method in the industry. Training, particularly of supervisors, is now being given greater attention in the industry than ever before. Many companies, such as Crossley Brothers, Ltd., and R. A. Lister and Co., Ltd., are running well-equipped apprentice training schools.

It is almost impossible to assess precisely what effect an event such as a productivity team's visit has had on any industry, especially one which is virile and expanding. The team's report has been thoroughly discussed. It might have been of advantage for more individual companies to have been visited by the team, or for a general conference to have been held to discuss the report; but the proof of the pudding is in the eating. In any case many potent influences apart from the team's report, such as the awareness of an expanding market and intensified commercial competition especially in overseas markets, have combined to encourage what is a process of thorough overhaul and reorganisation during the post-war period.

South Fremantle Power Station

(Contributed)

One of the more important projects now under way for the development of electrical power in Western Australia is the construction of the new 100MW generating station at South Fremantle, which is being built in two sections, "A" and "B." The "B" station boiler and turbine houses, when completed, will duplicate the present plant in the "A" station, which was opened a year ago by the Western Australian Minister for Works and Electricity. When completed, South Fremantle power station will bring the total generating capacity available to metropolitan consumers in Western Australia to almost three times the amount existing in 1945. This increase is indicative of the enormous growth in demand which has taken place and gives every indication of continuing in the future; it is based on Western Australia's good fortune in having an adequate source of fuel for the new power station—the coal mines at Collie.

The complete power plant installation will consist of four 25MW turbo-alternators served by eight water-tube boilers, each having a normal evaporation of 125,000 lb per hour at 630 lb per square inch pressure and 830 deg. Fah. superheat. The boilers are three-drum bent tube units, with separate steam receiver and are fired with pulverised sub-bituminous non-coking coal railed from the Collie deposits. Provision has been made for emergency oil firing. The turbines are horizontal, two-cylinder impulse, machines, running at 3000 r.p.m., with stop valve conditions of 600 lb per square inch, 800 deg. Fah., exhausting to a vacuum of 28in mercury with cooling water at 80 deg. Fah. The alternators have a maximum continuous rating of 25MW at 0·8 power factor with 22kV generating voltage at 50 c/s.

This frequency represents the first stage in bringing Perth into line with the main Australian States. It eliminates the need for the special equipment required by the present 40 c/s system. To effect the change-over, the new station has been connected by some 15 miles of 66kV overhead transmission lines to a recently installed 25MW frequency changer at the East Perth Station. In the initial stages the changer will convert the power from South Fremantle to 40 c/s for distribution over the present metropolitan system. Preliminary work for the conversion necessary to change the present system from the non-standard frequency of 40 c/s to 50 c/s is now proceeding and later, when this work is completed the frequency changer will convert the output from the old station to the new 50 c/s frequency.

Preparation of the site and all work up to ground level was carried out by the Harbours and Rivers Branch of the Public Works Department of Western Australia. The piling and concrete work for the footings, the excavation and concrete of the pump well and crusher house pit, the concreting of the heavy alternator foundations was done by them, as well as all sea front work.

The contract for the installation of the two turbo-alternators, condensers and switchgear for the "A" station was awarded to Metropolitan-Vickers Electrical Company, Ltd., of England, but that for the "B" station is held by its Australian associate—the Australian General Electric Pty., Ltd.,—for identical equipment. Our illustration shows the interior of "A" section, equipped with Metropolitan-Vickers turbo-alternators. Most of the steelwork has been fabricated in Perth of Australian steel, by the Broken Hill Proprietary's associated organisation, the Structural Engineering Company of W.A. Pty., Ltd., which was also responsible for the design and erection of the main building, including the coal bunkers and chimneys, as well as for the supply of all building and most of the plant steelwork.

The State Electricity Commission of Western Australia has made a close study of providing supply in the comparatively sparsely-populated rural areas outside the main towns and villages, and when the transmission lines of its country schemes are in operation, it will be extending single-phase high tension lines into these areas to give supply to individual farms.

Turbine Hall, South Fremantle Power Station

The British Association

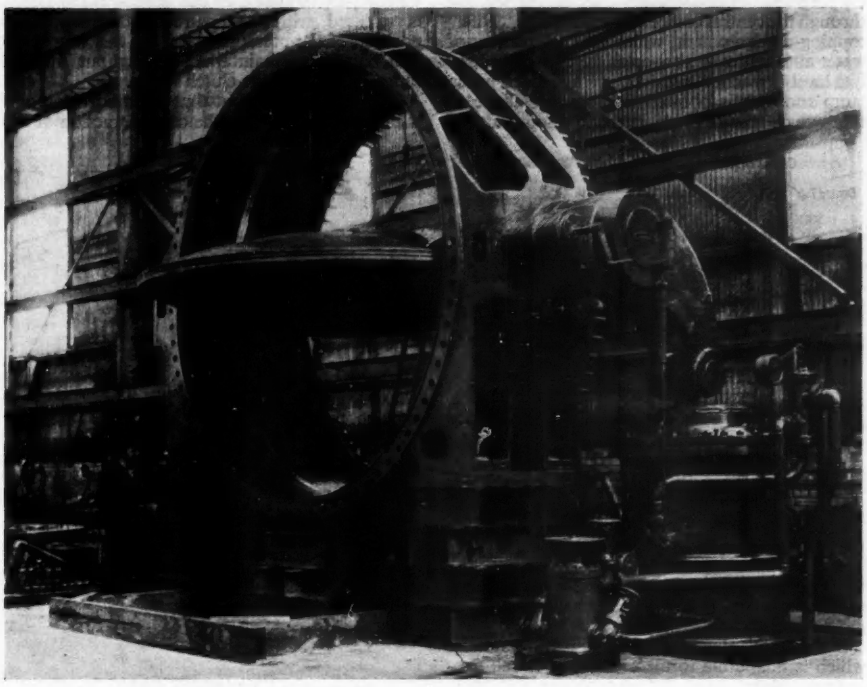
THE 114th annual meeting of the British Association for the Advancement of Science will be held in Belfast, under the presidency of Professor A. V. Hill, C.H., F.R.S., from Wednesday, September 3rd, to Wednesday, September 10th. The full programme for the meeting has now been issued, giving details of the general and sectional sessions and of the visits and other functions which have been arranged. The first general assembly of members will take place in the Sir William Whitla Hall of Queen's University, Belfast, on Wednesday evening, September 3rd, at 8 p.m., when honorary degrees will be conferred by the Chancellor of the University, Field-Marshall the Viscount Alanbrook, K.G. Following this ceremony, Professor Hill will deliver his presidential address entitled "The Ethical Dilemma of Science."

The sectional meetings of the Association will begin on Thursday morning, September 4th, those of Section G (Engineering) being held at the Methodist College, Malone Road, Belfast. Sir Ben Lockspeiser, F.R.S., is president of this section, and he will deliver his address on "Progress in Aeronautical Science and Engineering" on Friday morning, September 5th at 10 a.m. It will be followed by a paper by Dr. Denis Rebbeck, a vice-president of the section, entitled "Ships and Shipbuilding in Belfast." This session will take place at the Sir William Whitla Hall, Queen's University. The programme for Section G on Thursday, September 4th, includes a joint session with Section I (Physiology) at which there is to be a discussion on the "Biology of Flying." Other papers to be presented that day are on "Vibrated Concrete," by Mr. D. A. Stewart, and "Calculation of Transmission Line Constants," by Professor R. O. Kapp. On Monday, September 8th, the papers to be discussed are: "The Shape of Wings to Come," by Mr. D. Keith-Lucas; "Future Development of the Flying Boat Airliner," by Mr. H. Knowler; "The Training of Chemical Engineers," by Professor D. M. Newitt, and "The Chemical Engineer in Industry," by Dr. E. H. T. Hoblyn. On Tuesday, September 9th—which is the final day of Section G meetings—there are to be papers on "Servo-Mechanisms in Aircraft," by Mr. F. W. Meredith, and "Ships and Servo Mechanisms," by Lieut.-Commander J. R. D. Walker. In addition, there will be presented for discussion a group of papers by young engineers, as follows: "The Analysis of Statically Indeterminate Structures by the Complementary Energy Method," by Mr. T. M. Charlton; "The Effect of Shot Peening on the Fatigue Life of Steel," by Mr. A. G. H. Coombs; "Textile Engineering," by Mr. A. V. Pringle, and "The Bending Strength of Corrugated Plate," by Mr. J. B. Caldwell. The list of visits arranged for members of Section G includes an all-day excursion on September 6th, to the Silent Valley Reservoir.

As usual, in other sections of the Association there will be discussions of interest to engineers. In Section A (Mathematics and Physics), for example, the morning session on Friday, September 5th, will discuss "The Physics of the Higher Atmosphere," while on Monday morning, September 8th, a group of papers on "Electrical Discharges in Gases," is to be presented. Professor A. M. Tyndall, F.R.S., is the president of the section, and his address, which will be delivered on Thursday morning, September 4th, is entitled "Contributions to Experimental Physics from Britain." In Section L (Education) one of the papers to be discussed on Friday, September 5th, is by Major-General C. Lloyd, entitled "Higher Technological Education."

During the meeting, there are to be three special evening discourses. One of them—in the Sir William Whitla Hall, Queen's University—will be given by Mr. A. C. Hartley, M.I. Mech.E., on Friday, September 5th, at 8 p.m., the subject being "Oil in Peace and War." Another special event is the exchange lecture of the British and American Associations for the Advancement of Science, which will be delivered on Thursday, September 4th, at 5.30 p.m., in the Sir William Whitla Hall, by Dr. D. W. Bronk, president of the American Association.

The headquarters of the Association throughout the meeting will be situated in the University Library, Queen's University, Belfast.



13 ft diameter Balanced Disc Valve

Large Sluice Valves

THE first of three large turbine inlet control valves for the Los Peares hydro-electric station on the River Mino in North-West Spain has recently been completed by Glenfield and Kennedy, Ltd., to the order of Boving and Co., Ltd. It is shown in the accompanying illustration.

These valves, which are of the balanced disc type, are each 13ft in diameter, some 65 tons in weight and when closed under the maximum working head will carry a load of about 1100 tons on the door. They are operated hydraulically by a servo-motor, which is supplied with oil from the turbine governing system, and are provided with a motor-driven by-pass valve, the entire sequence of operation of the valves being automatically controlled. The turbines are Francis machines, each rated at 72,800 b.h.p., at 214 r.p.m. under a maximum operating head of 93·32m with a flow of 66 cumecs. The turbines have been designed to operate, with a reduction in output, at heads down to 67·73m, at which head the output will be 53,000 h.p., the turbines giving their highest efficiency at their lowest operating head. The alternators are each rated at 62,400kVA and generate at 11kV.

15MW Gas-Turbine Generator at Trafford Power Station

THE first gas-turbine generator to be commissioned by the British Electricity Authority—a 15MW set, built by Metropolitan-Vickers Electrical Company, Ltd.—was put on load recently at Trafford power station, Manchester. It operates on an open compound cycle and consists of a low-pressure compressor, an air intercooler, a high-pressure compressor, a heat exchanger, a main combustion chamber, a high-pressure turbine, a reheat combustion chamber, and a low-pressure turbine; the air passes through these components in the order named, and the exhaust from the l.p. turbine passes back through the heat exchanger before being discharged to the stack.

The low-pressure turbine is directly coupled to the low-pressure compressor and to the 15MW alternator; it runs at a speed of 3000 r.p.m. under the control of a speed governor operating on the fuel admission to both combustion chambers. The high-pressure turbine is coupled to the high-pressure compressor and runs at a speed which is determined by the load conditions and is 5500 r.p.m. at full load. A 400 h.p., a.c. motor coupled to the high-pressure units is used to start the set, the motor being automatically declutched when a self-sustaining speed of about 3000 r.p.m. is reached. At first, gas oil will be used as the operating fuel but later it is hoped to modify the plant to use heavier grade oils.

Before admission to the low-pressure compressor, the incoming air is passed through an electrostatic filter, which relieves the air of solid impurities that would otherwise impair the efficiency of the compressor blading. The exhaust gases leaving the heat exchanger, which is analogous to the economiser in a steam plant, are passed to a reinforced concrete stack, 250ft high. To withstand the operating temperature of the order of 1200 deg. Fah. the blading is made of alloys consisting mainly of nickel and chromium, with only minute quantities of iron.

Leak-proof Alkaline Cap-lamps

FOLLOWING extensive investigations into the causes of electrolyte leakage from miners' cap-lamps, Nife Batteries, of Redditch, Worcs, has introduced a new nylon safety vent, which ensures that all alkaline cap-lamps can now be operated in a completely dry external condition.

Vent leakage was found to be due to one or more of four different causes: spraying during charging, the ejection of liquid under pressure through the vent while the lamp is in service, over topping-up and badly fitting seating washers. Internal gas pressure during charging is responsible for the first two, the human element for the third and the repeated removal of vents before topping-up for the fourth, it is stated.

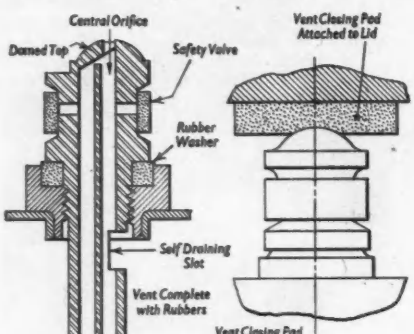
The "Nife" nylon safety vent, which is shown diagrammatically herewith, is stated to eliminate all these faults.

The opening of the cap-lamp battery lid for charging, automatically opens the central orifice of each vent so that charging gases can escape without hindrance. The body of the vent contains two columns of unequal height, and these, combined with a self-draining slot and a free gas exit, remove all possibility of electrolyte spray. At the end of the charge the cells are at atmospheric pressure and their tops completely dry.

On closing the battery lid the cells are sealed at atmospheric pressure. This ensures, in conjunction with the self-draining device, that no leakage takes place in service, even though the lamp is operated for long periods in a horizontal position.

It is not necessary to remove the vents before

topping-up. This operation may be carried out through the central orifice by means of the "Nife" topping-up equipment, which cuts off the flow of water automatically as soon as the correct electrolyte level is reached. Besides saving labour in the lamp room, it is pointed out, the avoidance of the weekly removal of perhaps thousands of



Leak-proof Alkaline Cap-Lamps

vents with the attendant dangers of careless replacement or badly seated washers, has removed a major cause of leakage.

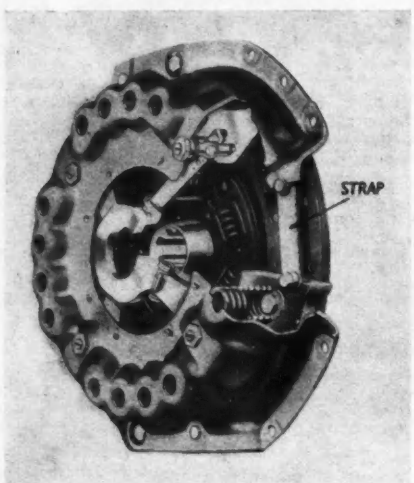
Several advantages are claimed for this system, which is adaptable to all "Nife" three-cell cap-lamps. Maintenance is made easier and costs are reduced by the absence of spillage, since only distilled water is necessary for topping-up and there are no moving parts.

Clutches for Commercial Motor Vehicles

We have received from the Automotive Products Company, Ltd., particulars of a new Borg and Beck clutch which has been introduced for use on commercial motor vehicles. These new "A.S." clutches are made in a 12in and a 13in size to transmit relative maximum torques of 250 lb/ft and 290 lb/ft in petrol engine and 210 lb/ft and 245 lb/ft in diesel engine service, the maximum rotational speed being 3000 r.p.m.

The arrangement of one of the new clutches can be seen in the photograph we reproduce. They rely for the transmission of the drive from the cover pressing to the pressure plate upon a group of four pairs of tempered steel straps. One end of each pair of straps is riveted to the cover flange, whilst the other end is bolted to the pressure plate. The straps are arranged tangentially so that they can deflect as the clutch is released without disturbing the concentric position of the pressure plate. In this way accurate balance is maintained throughout the full range of travel of the clutch levers.

The makers point out that an important point with this design is that the centring action of the



Improved "A.S." Motor Vehicle Clutch

straps does not depend on the tightness of the rivets and bolts since in order for the pressure plate to move off centre it would be necessary for the length of two or more straps to change. As this change is not possible, off-centre shift of the pressure plate cannot occur. It is claimed amongst other things that this new strap drive eliminates wear and noise, and that there is an improved inherent balance.

Horizontal Drilling Machine for Boilers

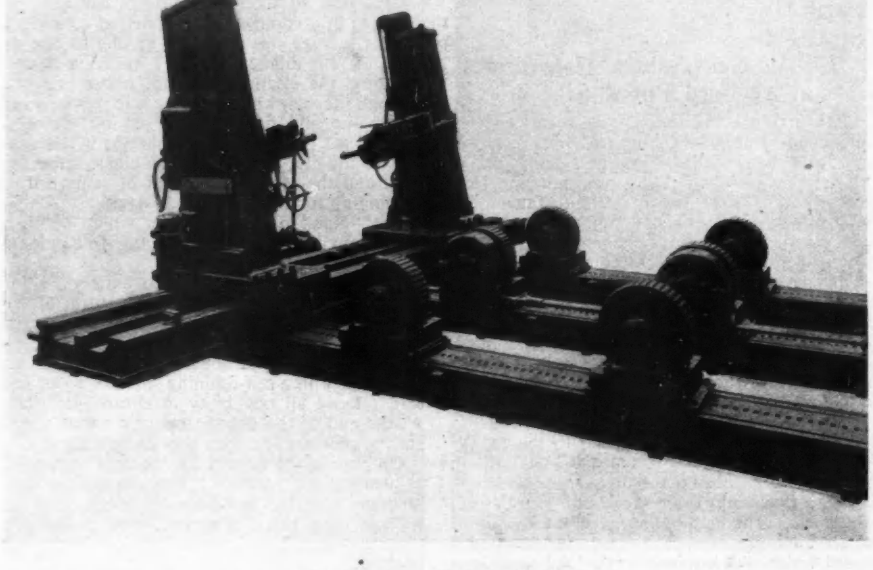
One of two special horizontal drilling machines recently completed by Kitchen and Wade, Ltd., of Halifax, for the Morts Dry Dock and Engineering Company, of Sydney, is illustrated below. This double-headed machine is intended for drilling boilers ranging from 6ft to 20ft diameter by 18ft long. It is built with right- and left-hand heads so that a single operator can control the two drilling heads efficiently.

Each of the heads is driven by a built-in motor, and has a range of six spindle speeds and three rates of feed. The 2in diameter spindles are bored No. 4 Morse taper in the nose and an 18in length of feed traverse is provided.

The saddle vertical traverse and the column horizontal motions are power-operated, controlled by flush-mounted push-buttons on the saddle. The saddle vertical traverse incorporates an alignment motion which automatically swivels the saddle, on its being moved vertically, to keep the drill spindle pointing towards the centre of the boiler at all positions. Automatic lubrication to the saddle mechanism and the column slideways is provided by built-in pumps.

The boilers to be drilled are mounted on the six rollers to be seen on the beds in front of the machine. On these beds the rollers can be set in the required positions according to the diameters of the boilers whilst the two centre rollers can be rotated by power to turn a boiler so that it can be drilled all round at one setting.

The other horizontal drilling machine has two independent and completely self-contained heads, mounted on one column, and its table bed slideways carry a 6ft 6in diameter work table. This table can be rotated by power and it is also traversed along the bed by an independent motor drive.



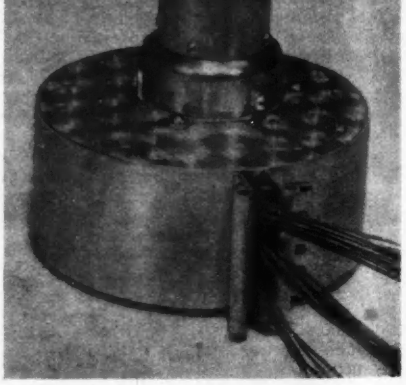
Special Horizontal Drilling Machine

American Engineering News

(By our American Correspondent)

A Ten-Channel In-Flight Calibrator

A ten-channel in-flight calibrator which has been developed by the National Bureau of Standards uses an interesting system of cam-operated switches which eliminates many of the difficulties encountered in calibrators of comparable size and scope. Designed to identify telemetered information from a guided missile in flight, the device is compact and is designed to suit telemetering applications in aircraft, missiles



10 Channel In-Flight Calibrator

or projectiles. The initial model, which was designed by the N.B.S. guided missiles laboratory, is now being manufactured by the J. P. Seeburg Corporation, of Chicago. Telemetering involves the measurement of one or more quantities by electrical instruments, the transmission of the data to a distant receiving station, and the receipt and recording of the measured quantities. The information is usually transmitted by wireless, although under some circumstances it may be carried by wire. The transmitted signals may be derived from transducers or pick-ups which translate mechanical movement into electrical impulses, or they may be derived through direct coupling to electrical circuits.

Normally the information is then used to modulate a high-frequency radio carrier.

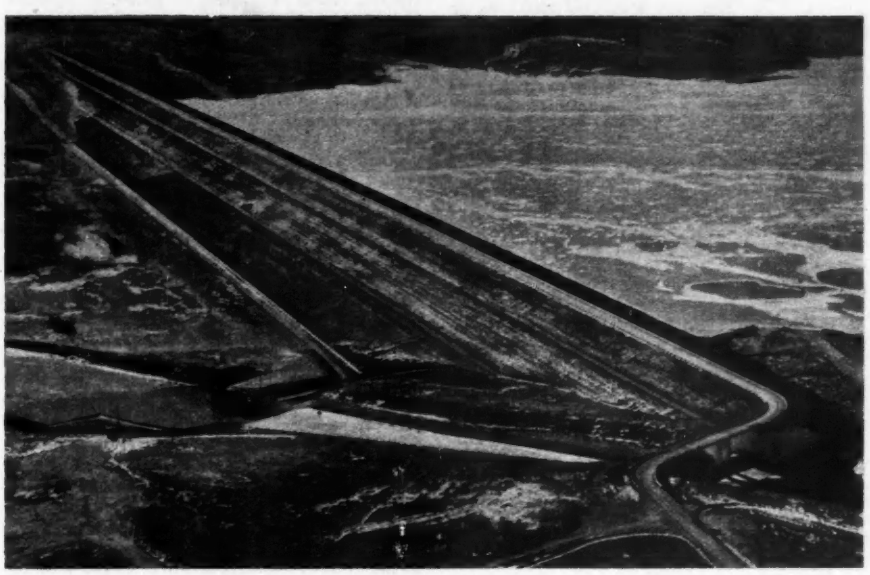
At the receiver-recorder it has been found to be virtually impossible to assign any finite value to the received information until two or more reference levels of modulation have been established in terms of the response of the receiving equipment. The calibrator supplies each intelligence channel in turn with four known levels of modulation. Thus, the telemetering record is provided with known reference levels of modulation from which the received data may be interpreted. Transmission control of the calibrating signal, as well as the " data " signal, is achieved through the action of two groups of noise-free switches involving forty separate switching operations. The first group contains ten single-pole double-throw switches operated in sequence by a motor-driven cam. Its function is to interrupt briefly and periodically the normal channelling of the operating information to the r.f. transmitter and to connect the calibrating circuit to the output instead. The second switching group contains four single-pole single-throw switches, also operated by a motor-driven cam. The function of this group is to pass step-calibrating signals in sequence to the transmitter during the interval in which a particular telemetering channel is interrupted by the first group of switches. The step-calibrating cam cycles ten times for each cycle of the channel-interrupting cam ; each interrupted channel receives identical calibrating signals. All switches and cams are contained within a cylinder about 2in long and 4in in diameter, which is shown in the accompanying illustration. The drive motor for both cams is mounted at one end of the calibrator. The calibrator could easily be expanded to permit operation of twenty telemetering channels. This would only involve installation of ten more switches, increase of the width of the slow-speed cam, and an enlargement of the calibrator housing to accommodate the additional switches. Such an arrangement would permit two channels to be calibrated simultaneously ; each channel would be recalibrated every ten calibration cycles. The four reference calibration levels supplied by the calibrator to the transmitter are usually chosen so as to divide the total modulation range into equal parts on the record. Thus, the traces of the calibration signals not only form a basis for assigning calibration values to the record but also provide a means for correcting for any non-linear qualities of the transmitter and receiver-recorder.

The N.B.S. in-flight calibrator has been found to perform satisfactorily under a wide range of drive motor speeds ; however, the optimum speed for in-flight operation of the high-speed cam is approximately 200 r.p.m.

Dedication of Bonny Dam in Colorado

The dedication took place on June 1st of the Bonny dam of the U.S. Bureau of Reclamation in Eastern Colorado. Although it is not a particularly large structure, in comparison with other schemes of the Bureau, it is, nevertheless, of considerable local importance to an area which has suffered seriously from flood damage in the past. The Bonny dam is situated on the South Fork of the Republican River, near the town of Hale, Colorado, about 6 miles west of the Colorado–Kansas State line. The dam is a major structure of the St. Francis installation of the Missouri River Basin project, and was designed by the U.S. Bureau of Reclamation as a multiple-purpose structure providing for flood control, irrigation, silt storage and other benefits. The primary purpose of the dam is the protection of the lower South Fork Republican River Valley below Benkelman, Nebraska, from recurring floods originating in the South Fork of the Republican River above Hale, Colorado. The estimated frequency and magnitude of floods occurring above Bonny dam which can be wholly or partially controlled by this dam makes it one of the more important flood control dams in the Republican River Basin above the Harlan County dam, which is a project of the U.S. Army Corps of Engineers and was recently completed. In addition to flood control, the Bonny reservoir will provide irrigation storage for some 6000 acres of new land and a supplemental water supply for 520 acres of land which are, at present, irrigated inadequately. Although the irrigation phase of the project was considered to be in conflict with existing agreements between the States of Colorado, Kansas, and Nebraska governing the distribution and utilisation of the waters of the Republican River and its tributaries, Congress, nevertheless, appropriated funds for the construction of the dam, primarily for flood control purposes. Studies are now in progress to determine the most practicable plan for the development of the irrigation potentialities without violating the existing agreements.

The project is situated in a semi-arid region of the Great Plains normally deficient in precipitation and subject to recurring drought and hot, dry, summer winds. The area is also subject to occasional storms of very great intensity which transform its normally quiescent streams into uncontrolled torrents. The dam was designed by the Bureau of Reclamation primarily to retain these flood waters for later release to lands downstream. Of the 175,000 acre-feet of storage capacity in the reservoir, 132,000 acre-feet are allocated to flood control, the remaining 43,000 being reserved for irrigation and silt retention purposes. In addition to the flood control and irrigation features, recreational facilities, already completed or to be constructed in the reservoir area in the future, will provide fishing, boating, camping and swimming in an area now lacking such facilities.



Bonny Dam and Reservoir

A contract for the construction of the Bonny dam and access road was awarded to the Utah Construction Company of San Francisco, California, on November 4, 1948. Notice to proceed with the work was received by the contractor on December 7, 1948, and, since a period of 1400 days was allowed in the specifications for the completion of the work, the contract completion date was set as October 7, 1952. On December 8, 1948, construction was begun and the dam and access road were completed and accepted by the Bureau of Reclamation on May 4, 1951, 521 days ahead of schedule. The total cost of Bonny dam and its appurtenant works constructed to date has been approximately 13,000,000 dollars.

Bonny dam, which is shown in the accompanying illustration, is a rolled earth-fill structure rising 128ft above the river bed. It is 9265ft long and some 8,554,000 cubic yards of embankment material were used in its construction. A roadway 30ft wide has been built along the dam crest, with a concrete bridge spanning the spillway opening at the north abutment. The overflow weir spillway is 100ft long, is situated at a crest elevation of 3672ft, and has a capacity of 64,700 cusecs. A gravel-surfaced road, 3 miles in length, was constructed to provide access to the dam from the north. This road extends from the north abutment of the dam to an east-west county road approximately 4 miles east of Colorado State Highway No. 51, and 2 miles west of Colorado State Highway No. 53. The construction of the spillway and outlet works structures required over 31,800 cubic yards of concrete.

Two stages of diversion were used by the contractor for carrying the river past the dam during construction. In the first stage, the river flowed through a temporary diversion channel excavated near the north edge of the river valley. In the second stage the river was diverted through an excavated channel south of the natural stream bed. This diversion channel functioned until the earth-fill had been constructed to a safe level and the spillway and outlet works had been completed to a point where these structures could safely handle flood waters. At that time, the metal culverts placed in the temporary cofferdam were plugged and emplacement of fill in the diversion channel through the dam was initiated. This was accomplished in July, 1950, and allowed the beginning of storage of water in the reservoir. The Utah Construction Company, as prime contractor, had full responsibility for the construction of the dam and the access road, and concerned itself primarily with the excavation of borrow material and the emplacement of the dam embankment, while most of the other work was sub-contracted. During 1949, the first full year of construction, the Utah Construction Company completed 43 per cent of the contract work on what was scheduled to be a four-year contract. In so doing, it established several new records for earth work on Bureau of Reclamation projects, excavating over 1,000,000 cubic yards of material a month for four consecutive months, with a maximum of 1,334,000 cubic yards in November, and placing over 1,043,000 cubic yards of embankment material in the month of November. The first load of earth-fill material was dumped on the dam in March, 1949, and the last load in November, 1950. Emplacement of concrete for the spillway and outlet works was begun in June, 1949, and these structures were completed in October, 1950. For the protection of the upstream face of the dam, a layer of rock riprap, 3ft thick, over a crushed rock or gravel blanket 18in thick was placed up to 3ft above the normal reservoir water surface. From that point to the top of the dam the riprap and gravel blanket diminish in thickness to 2ft and 1ft respectively. Protection of the downstream slope of the dam was provided by seeding the topsoil-covered embankment with a mixture of crested and western wheatgrass, biennial yellow sweet clover and barley.

Reservoir clearing operations were completed in April, 1950, and storage of water in the

reservoir was begun in July of that year. At present, the reservoir forms a lake over 3 miles long and a mile wide and covers 1620 acres. It has a shore line of 10½ miles. When the lake is full, it will be about 3½ miles long and 1¼ miles wide, and, under normal conditions, will cover 2042 acres.

It is significant that the Bonny dam was selected by the Bureau of Reclamation as the site of an upstream embankment protection experiment, designed to lower the costs of such protection work. A test embankment section was constructed on the south shore of the reservoir about ⅛ mile upstream from the dam. Because of the increasing cost in the United States of rock riprap ordinarily used in upstream embankment protection, the Bureau of Reclamation initiated a research programme to investigate riprap substitute several years ago. The investigations covered suitable binding and cementing materials and the making and testing of numerous mixtures to determine their resistance to erosion and weathering, freezing and thawing, saturation and other factors. The possible benefits to be derived from use of the two common cementing materials, Portland cement and asphalt cement, as binding agents for fine-medium and fine gravels became apparent early in the investigations. The tests on asphaltic mixtures, in addition to conventional stability and immersion tests, included prolonged tests in a wave-action machine which subjected specimens to rapid immersion and retraction from water, inducing high air and hydrostatic pressures on the surfaces of the specimens. At 40 cycles per minute some mixtures successfully withstood more than 2500 hours of continuous testing. The investigation of soil-cement mixtures followed conventional test procedures of freezing and thawing, wetting and drying, resistance to abrasion and weathering. The tests conducted on specimens of the selected soil-cement mixtures in the wave-action machine indicated high resistance to these destructive forces. Although valuable information was obtained from these laboratory investigations, the data could be used only for the basic designs of mixtures; adequate information could not be obtained on the behaviour of facings of such material placed on slopes and subjected to the full impact of field conditions. To obtain this information on both soil-cement and asphaltic concrete facings, the Bureau decided to construct a test embankment in the reservoir area of the Bonny dam last year.

The test embankment was placed approximately ⅛ mile upstream from the south end of the dam and was positioned to face north-west, the direction of prevailing winds during late autumn and winter storms. At expected normal water levels, the facings will be submerged to approximately two-thirds of their height. The wind fetch from the north-west will be about 2 miles, thus assuring appreciable wave development over the facings. In addition, the area is subjected to low winter temperatures which will produce freezing sprays and ice, and other severe conditions. The test embankment has a total length of 740ft, a crest length of 400ft, and a maximum height of 26ft. The slope of the embankment is 2 : 1, and the slopes of the ends 10: 1. The outer 10ft of the embankment was constructed of compacted impervious material similar to the impervious material in the Bonny dam. The remaining embankment consists of compacted pervious soil and random dumped fill. A total of 28,300 cubic yards of earth, obtained from adjacent borrow pits, was required in constructing the fill. Half the face of the upstream slope was surfaced with a 3ft thickness of soil cement. The remaining area was surfaced with asphaltic concrete varying from 6in to 18in in thickness.

All work on the experimental facings was completed by May 28, 1951, and water covered the facings to a depth of approximately 5ft by June 20th. As far as weather and precipitation conditions permit, water will be maintained at approximately one-half to two-thirds the height of the facings during the life of the test section.

The cost of the soil-cement facing, based on tendered prices, including the cost of all materials, was approximately 9 dollars a square yard for a 3ft thickness. The effective use of equipment, which included the placing of the earth embankment concurrently with the placing and mixing of the soil cement, the placing in horizontal lifts 10ft wide, and the use of a uniform thickness of facing, made possible low costs for this part of the work. The sub-contractor for the soil-cement construction stated that the cost of this type of work could be appreciably reduced on a large-scale installation. The cost of the asphaltic concrete facing, also based on bid prices and including the cost of all materials, was approximately 16 dollars per square yard, based on a 1ft thickness, the thickness tentatively indicated as desirable for slope protection. The high prices for the asphaltic concrete were due largely to the rental and transport costs of special equipment, such as the mixing plant and dryer, finishing machines and rollers. At this time, the relative merits of the two materials are being considered primarily on the basis of their behaviour during prolonged periods of service rather than of indicated construction costs. However, the installation of the experimental facings at the Bonny reservoir are expected to contribute much toward a better evaluation of the construction cost of these two materials when applied to slope protection of dams.

Keel Laying of the U.S.S. "Nautilus"

On June 14th, the keel was laid at the Electric Boat Company's yard at Groton, Connecticut, of the U.S.S. "Nautilus," believed to be the first submarine in the world to be powered by nuclear energy. The ceremony took place in the presence of President Truman, and in his dedication speech he said that "this vessel is the forerunner of atomic-powered merchant ships and airplanes, of atomic power plants producing electricity for factories, farms and homes. The day that the propellers of this new submarine first bite into the water and drive her forward will be the most momentous day in the field of atomic science since that first flash of light down in the desert seven years ago. Then we knew we had a bomb for war. Now we will have a working power plant for peace." The vessel is expected to be ready for her first sea trial in 1954. The U.S. Atomic Energy Commission, in co-operation with the U.S. Navy, has already built a submarine hull at the Arco experimental station in Idaho and will use it to test a full-size development model of the engine to be used in the "Nautilus."

A Steam and Gas Turbine Development Laboratory

Ground was broken recently for a steam and gas turbine development laboratory at the South Philadelphia works of the Westinghouse Electric Corporation. Construction of the four-storey brick and structural steel building will begin late this summer, and will take about a year to complete. The laboratory will employ a staff of nearly 100 engineers and technicians, and initially will conduct special research for the U.S. Air Force. Steam and gas turbines up to 15MW capacity will be accommodated in the main test hall of the new research building. Three 8000 h.p. axial-flow compressors will provide facilities for the development of compressors to be used in conjunction with gas turbines and the Air Force wind tunnel. Separate laboratories will be provided for hydraulic, heat exchange, mechanical, aerodynamic, combustion, and model shop activities. The laboratory power station will include a boiler providing 150,000 lb of steam per hour at a temperature of 900 deg. Fah. A reheater at the laboratory, used in conjunction with reducing valves, will make available steam at any desired pressure of up to 1500 lb per square inch and at temperatures ranging from 800 deg. to 1100 deg. Fah. United Engineers and Constructors, Incorporated, of Philadelphia, will construct the new building according to specifications developed by the Westinghouse Engineering and Research Departments in Pittsburgh, Pa.

"BULLETIN OF ELECTRICAL ENGINEERING EDUCATION."—Among the articles appearing in *The Bulletin of Electrical Engineering Education* (No. 8, May, 1952) is one by Professor C. E. Moorhouse, describing a graphical approach to measuring instruments. This publication also includes a discussion on phase sequence detecting circuits by David Morris, and an article on waveform clipping by intervalve C.R. coupling circuits. The *Bulletin* is published by the Manchester Municipal College of Technology, Manchester, 1.

French Engineering News

(By Our French Correspondent)

The French steel industry is to have a new seven-year production and development plan, which will increase steel output in France to 20,000,000 tons per year. Last year, France produced 9,832,000 tons of steel ingots, or 100,000 tons more than in 1929, which was a record year. Finished products made even greater progress, and reached 7,046,000 tons against 6,528,000 tons in 1929.

If the Saar is taken into account, production last year reached 12,435,000 tons of steel ingots. This brings the Franco-Saar steel group into third place after Britain and Germany in Western Europe. In May this year, France and the Saar produced 1,178,000 tons of ingots, which corresponds to an annual production of 14,000,000 tons.

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The United States is to import certain kinds of French radial drilling machines to be used in the building of aircraft engines. Orders to the value of one million dollars have been placed. Ten machines have already been delivered, and 162 others are being built. These machines are being built by the Ateliers G.S.P.

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The annual report of the nationalised Renault works shows that production in 1951 was higher by 25 per cent than in 1950, and that Renault is turning out 65 per cent more vehicles than the next largest manufacturer in France. In 1951, the "regie" turned out 99,886 of its small 4 h.p. cars, against 86,077 in 1950; other kinds of vehicles were also produced in greater numbers. The report expresses fears over recent rises in the cost of non-ferrous metals, and says that if these continue, the export of Renault cars will be jeopardised. It places great hopes in the success of the Schuman Plan which should stabilise raw material prices.

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Overhead cableways for the handling of coal and ash have been installed at the Pont-de-Menat thermal-electric power station. The station is connected by a bi-cable ropeway with the mines at Saint Eloy, some 10 kilometres away. The ropeway itself is 9900m long, rising, at its highest point, to 147m. It has an hourly capacity of about 30 tons, each skip holding 330kg. The skips move at a speed of 2·5 metres per second, normally with 99m between each skip. An 85 h.p. motor drives the cableway and the cables are carried on fifty-one pylons. The support cables are 22mm in diameter, with an 87,500kg breaking load. The haulage rope is 18mm in diameter, has a hemp core and a breaking load of 22,500kg. The skips are of welded sheet steel, and they can be coupled if necessary. Automatic control includes starting, uncoupling the skips on arrival, emptying and control of skips at the stations, and an automatic washing plant for the skips on a subsidiary cableway. The loading of skips is carried out in conjunction with automatic scales.

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The 12,000-ton "Charles Tellier" has come into service on the South American route. The new vessel is 163·6m in length and 19·6m in breadth. It has three decks and can carry ninety-three passengers first class and 326 passengers second class. The ship has been built primarily to carry food and has 3000 cubic metres of cold storage space.

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The latest figures given of the French merchant fleet show that on July 1st it represented 3,308,896 tons, against 2,733,633 tons in October, 1939. Statistics show that coal-burning ships have almost disappeared, there being only six, representing 36,000 tons, among the passenger vessels, with fifty-six ships burning oil, and twenty-three with diesel engines. Among cargo ships, seventy-six burn coal, 289 burn heavy oil and 370 have diesel engines. Finally tankers, which come into a special category, are split up as follows: thirty-eight heavy oil and sixty-seven diesel. The modernisation of French shipyards will enable some 200,000 tons of new shipping to be built every year. The only probable cause of a reduction in this figure, it is pointed out, is the lack of raw materials and supplies, particularly steel.

Industrial and Labour Notes

Engineering Wages

The seventeenth annual meeting of the Confederation of Shipbuilding and Engineering Unions is being held this week at Southsea. Mr. H. G. Brotherton delivered his presidential address on Tuesday last, during the course of which he pointed out that the most important matter before the conference was that of wages. The cost of living had continued to rise since the confederation's last annual meeting, he said, and though a modest wage advance had been negotiated towards the end of last year, there could be no doubt that the majority of the confederation's members were to-day worse off than they had been twelve months ago. Since the end of the war, Mr. Brotherton noted, the general pattern of the engineering industries had been one of steady expansion. A substantial share of the rewards of increased production, he continued, had been appropriated by the employers in the form of swollen profits. The assumption that the cost of wage increases must be passed on to the consumer was consequently one which the trade union movement could never accept, Mr. Brotherton went on, and to speak quite frankly, he thought it an assumption which violated elementary justice. He then commented upon Britain's export difficulties, which, he contended, arose not so much because our prices were non-competitive, but because other countries had reduced imports to meet their own balance of payments difficulties. The cause of these difficulties, he said, was to be found in world economic circumstances, and it was unreasonable to argue as though the wages of British workers were the determining element in the situation. Mr. Brotherton also stated that if the purchasing power available to the workers were to fall still further, it could lead to continued unemployment in certain consumer goods industries.

As mentioned in our issue last week, a special meeting of the Amalgamated Engineering Union took place on August 9th, to consider the employers' rejection of the claim put forward by the confederation for an increase of £2 a week in the wages of adult male workers in the engineering industry. The A.E.U., it is understood, proposed that a ballot on the alternatives of strike action or a ban on overtime and piecework should be taken during the course of the confederation's annual meeting.

Production Management Course

The British Institute of Management and the Institution of Production Engineers have jointly organised a residential course for senior executives of small firms in the engineering and general manufacturing fields, to be held at the College of Aeronautics, Cranfield, from September 21st to 27th. The course is designed particularly to appeal to firms undertaking defence contracts, but is not confined to them. The subjects will include administration and servicing of contracts; material supply and control; production management; quality and inspection requirements and organisation; personnel management, and costing. It is stated that the course is the first of its kind to be held in this country and will be of value to the executive of the small firm who wishes to remain abreast of changing production and management techniques. It will consist of a limited number of lectures, followed by discussions in groups led by the resident staff. A great deal of the time will be spent on demonstrations and in the workshops where the practical applications of the studies will be seen. Further details of the course may be obtained from the Course Secretary, The Institution of Production Engineers, 36, Portman Square, London, W.1.

Non-Ferrous Metal Prices

The Ministry of Materials has announced that from August 8, 1952, the price of good ordinary brand zinc has been decreased from £130 to £118 per ton delivered at the consumers' works. The premiums for higher grades of zinc remain unchanged, it is stated.

Further price reductions have been authorised by the Minister of Supply, who has made an order reducing the prices of secondary copper, brass, copper scrap, gilding metal scrap, brass scrap and cupro-nickel scrap to take account of the recent reduction in the Ministry of Materials selling price of virgin copper. For ingot bars or wire bars of secondary copper, the price per long ton has been reduced from £285 10s. to £283 10s. Reductions of a similar order have been made for the other categories listed. The order, the Copper, Zinc, &c., Prices (No. 4) Order, 1952, Statutory Instrument, 1952, No. 1465, came into force on August 7th; it may be obtained from H.M. Stationery Office, price 3d.

Metal Exports

The Board of Trade has announced that existing open general licences permitting the export of certain metal goods have been revoked, and new licences issued with effect from August 11, 1952. Tibet is now excluded from the countries to which these open general licences apply. The second change made is that the minimum value per ton of copper goods covered by the open general licences has been reduced from £700 to £500, and that for copper alloy from £600 to £420. The goods concerned are those specified in Group 6 (2) of the First Schedule to the Export of Goods (Control) (Consolidation) Order, 1952, and they include aluminium goods, copper goods, copper cables and wires, and iron and steel goods, whose values exceed certain specified amounts per ton of the metal content.

A New Index of Industrial Production

Using the results of the census of production for 1948, new weights have now been assigned by the Treasury to the different industries which make up its index of industrial production, and starting this month, the word "interim" will be dropped from the title and a new and improved index issued. In the four main groups of the index, totalling 1000, the weight given to building has been increased from 92 to 125, with a big reduction in the utilities group, and smaller ones in mining and manufacturing. In the manufacturing group (which is now almost exactly three-quarters of the total), textiles and paper and printing take a larger share than before, while chemicals and the metals-engineering-vehicles group take less. In the last named (which is rather more than a third of the full index and nearly half of all manufacturing) metals are weighted a little higher than before, and vehicles and engineering a little lower. The new index does not differ in purpose, and only very slightly in methods of compilation, from the one it replaces; but, in addition to using the 1948 census, it benefits from a number of detailed changes. For the time being, monthly figures have been carried back only as far as 1950, and annual figures only as far as 1948, but annual figures for earlier post-war years, it is stated, will be published later. In spite of the extensive revisions, the new index is very close to the old one. The revisions have had a greater effect on the indices for individual industrial groups however. For example, the new index for engineering, shipbuilding and electrical goods rises more rapidly. This is partly because of the use of additional production series, and partly because an improved system is used to allow for price changes. The new index for vehicles, on the other hand, rises much less rapidly than the old, owing to revised weights. A more complete account of the technical methods used in preparing the index is to be published by the Treasury as a separate memorandum. The revised index number of industrial production (1948=100) prepared by the central statistical office is estimated provisionally at 118 for May, 1952, compared with 111 for April, 1952. Figures for the corresponding months last year were 116 for May, 1951, and 122 for April, 1951. The figures for April, 1952, were affected by the Easter holiday, and for May, 1951, by the Whitsun holiday. On the basis of information so far received, the Treasury states, the index for all industries for June, 1952, is expected to be 109–110.

The Treasury's interim index of industrial production has been issued each month since February, 1948, by the central statistical office, thus giving a general measure of monthly changes in industrial production in the United Kingdom. The weights used for the different industries in the base year of 1946 were based upon estimates using the 1935 census as a starting point; it is these weights which have now been allocated more accurately based upon the 1948 census. As a comparison, the figures given by the interim index and the new index respectively are for 1949, 106·8 and 106·4, for 1950 116·2 and 113·5, for 1951 119·6 and 117·3, and for the first quarter of 1952, 122·3 and 120·2, the later differences being due to the 1950 discrepancy.

The Employment Situation

The Ministry of Labour's most recent survey of employment and unemployment in this country estimates that the total working population decreased by nearly 50,000 during June; at the end of June, the total working population numbered 23,436,000. Employment in the basic industries, the Ministry states, increased by 14,000 during the month, due, mainly, to an estimated seasonal rise of 10,000 in agriculture and fishing. The number of wage earners on colliery books increased by 1700. However, employment in the manufacturing industries, it is stated, decreased by 52,000 during June; the largest decreases are given as 28,000 in textiles and clothing, 18,000 in engineering, metal goods and precision instruments, and 20,000 in the "other manufactures" group—mainly in china and glass, timber and furniture and the paper and printing industries. It is estimated that there was no change in employment in building and contracting during the month. There were seasonal rises of 18,000 and 25,000 respectively in the groups classified as "food, drink and tobacco," and "professional, financial and miscellaneous services."

The total number of persons registered as unemployed at July 14th, the Ministry states, was 393,500 (of whom 101,100 were temporarily stopped), a decrease of 46,600 since June 16th; of the total 132,300 had been unemployed for more than eight weeks. The numbers of persons registered as unemployed in textiles decreased by 41,500, the Ministry reports. Some part of this reduction, it is stated, is due to unemployed workers not registering owing to the customary holidays in certain towns of Lancashire and Yorkshire. The July unemployment figure represented 1·9 per cent of the estimated total number of employees compared with 2·1 per cent in the Ministry's survey for June and 0·9 per cent for July, 1951.

The Schuman Plan

On August 10th, the inaugural meeting of the High Authority of the European Coal and Steel Community was held in Luxembourg. There are nine members of the High Authority, which is concerned with coal and steel production in France, West Germany, Holland, Belgium, Luxembourg and Italy. The chairman of the Authority, Monsieur Monnet, made an inaugural speech, in which he spoke of the importance of the High Authority and of its supra-national character. Customs barriers and similar discriminations on coal and steel supplies within the community would soon be eliminated, he said.

A statement was issued by the Foreign Office on August 11th, welcoming the establishment of the High Authority. The closest possible association would be established, it was stated, between the British Government and the High Authority. The chairman, Monsieur Monnet, was soon coming to London, the statement continued, to discuss the question of British relationship with the newly constituted coal and steel community.

Notes and Memoranda

Air and Water

RETURN OF DESTROYERS.—The Admiralty announces that Russia has agreed to return two destroyers, H.M.S. "Lincoln" and H.M.S. "Georgetown," which were lent to the Soviet Navy in 1944, and that the tug, H.M.S. "Warden" is shortly proceeding to Murmansk to tow away the first vessel.

THE LATE MR. P. M. HILL.—We have learned with regret of the death of Mr. P. Maurice Hill, who died suddenly on August 5th, at his home in St. Ives, Cornwall. Mr. Hill, who was sixty years of age, was formerly the general manager of the Chamber of Shipping, a post from which he retired in 1950, due to ill health.

OIL POLLUTION.—The first of the "Kon-Tiki" drift experiments, which form part of the research into the causes of oil pollution of sea water, has been completed. After following the drift of oil discharged at sea, the observation vessel, the yacht "Gay Caprice," returned to port ready to sail again on another drift experiment with a starting point 100 miles off the coast.

CONCRETE JETTY.—The Docks and Inland Waterways Executive announces that the British Transport Commission has approved the construction of a concrete jetty at Blacktoft, on the River Ouse, for the mooring of vessels using Goole Docks. The new jetty will replace an old wooden structure and be 654ft in length by 35ft wide, with a mean depth of 15ft at low spring tides.

THE SHIPBUILDING CONFERENCE.—The Shipbuilding Conference announces that the offices of chairman and deputy chairman are being discontinued and that two new appointments, namely, director and controller, have been created. Mr. R. B. Shepheard, C.B.E., who was until recently the chief ship surveyor of Lloyd's Register of Shipping, will take up his duties as director at the beginning of October, and Mr. Alexander Belch, C.B.E., who has been deputy chairman of the Conference since 1937, will be controller. In addition Mr. Belch has been appointed Chairman of Shipbuilding Corporation, Ltd., a director of the Ship Mortgage Finance Company, Ltd., and a director of National Shipbuilders Security, Ltd.

WATER SUPPLIES IN NORTHERN RHODESIA.—We have received a copy of the report for the year 1951 of the Water Development and Irrigation Department of Northern Rhodesia. Much of the work which the department is carrying out is unspectacular, judged by the standards of the larger civil engineering projects in progress in many countries, but is, nevertheless, of importance in providing the fundamental necessities of water for drinking and irrigation. A large part of the work in 1951 was concerned with the construction of earth dams, of which thirty-five were completed during the year: in the southern province three large dams were completed, one of which, Kabulamwanda, is believed to be one of the biggest in the territory, having a wall length of 600 yards and a length of impounded water at spill level of 4 miles. Other works in 1951 included the completion of eight weirs, 266 wells, and the drilling of boreholes with a total footage of 16,836ft.

Miscellanea

DIESEL GENERATING PLANTS.—The Canadian Standards Association approval has been received by Dale Electric (Yorkshire), Ltd., for the company's automatic, semi-automatic and hand control diesel generating plants.

POST GRADUATE COURSES IN ELECTRICAL ENGINEERING.—Details of a number of post-graduate courses in electrical engineering and applied physics are given in a prospectus (No. 2) published by the South-East London Technical College, Lewisham Way, London, S.E.4.

SITE RECORDS FOR BUILDERS.—The Ministry of Works has published a booklet entitled "Site Records for Builders—Programming and Progressing for Traditional House Building," with the object of assisting the drive to improve housing production. The booklet is obtainable from H.M. Stationery Office at a price of 3s.

A LARGE AXIAL FLOW MINE FAN.—With reference to the article "A large Axial Flow Mine Fan," which appeared in our issue dated July 25th, we have been asked by Walker Brothers (Wigan), Ltd., to state that the blade tensioning device described in the article has been patented by S.K.F., Gothenburg, represented in this country by Skefko Ball Bearing Company, Ltd., Luton.

THE IDENTIFICATION OF THREADING DIES.—A new edition has been published of a useful little book, "The Identification of Threading Dies," which was first issued by W. H. A. Robertson and Co., Ltd., of Lynton Works, Bedford, in 1948. The new book gives particulars of thread rolling dies which have been added to the firm's products, and it also gives details of some 300 different chaser dies and notes on no less than sixty different series of the principal thread systems of the world. All users of dies and chasers will find this a very useful book of reference.

BRITISH ELECTRICITY AUTHORITY.—Replying to a recent question about the forthcoming reappointment of the British Electricity Authority, the Minister of Fuel and Power said that he had reappointed Lord Citrine as chairman of the Authority and Sir John Hacking and Sir Henry Self as deputy chairmen. He was also reappointing two other existing members of the Authority —Dame Caroline Haslett and Lieut.-Col. E. H. E. Woodward. In accordance with the provisions of the Electricity Act, 1947, four chairmen of Area Electricity Boards (at present Mr. H. H. Mullens, Mr. H. Nimmo, Mr. S. F. Steward and Mr. C. T. Melling), and also the chairman of the North of Scotland Hydro-Electric Board, the Rt. Hon. Thomas Johnston, would continue to be members of the Authority. Two members of the Authority, Sir William Walker and Mr. Bussey, would retire. The Minister added that he had appointed Councillor J. Sullivan, at present a member of the South-West Scotland Electricity Board, as a member of the Authority and that he proposed to fill the other vacancy shortly.

POWER FACTOR CORRECTION.—The Federation of British Industries, 21, Tothill Street, London, S.W.1, has published a monograph entitled "Power Factor Correction," which is the sixth in a series of fuel economy monographs issued by the Federation in recent years. It is a practical guide to firms who may be in a position to improve the power factor of their electricity supply—an improvement which offers solid advantages, including the possibility of reduction in electricity charges. The booklet describes the various methods that can be used to correct poor power factor and includes nomograms, from which the necessary corrective capacitance can be calculated.

MR. J. BAPTIST KRAMER.—We regret to report that Mr. J. Baptist Kramer died at Kingussie, Inverness-shire, in his seventy-eighth year. Mr. Kramer, who was an inventor and a pioneer in the application of magnetism as an industrial tool, founded the Witton Kramer Electric Tool and Hoist Works in 1909, and was general manager of the works until his retirement in 1939. He was well known for his contribution to the development of magnetic cranes and the use of photo-electric cells as detectors. During the last war he worked on anti-submarine equipment, a ship's smoke detector, and a safety device for use in handling unexploded bombs.

DUNKIRK REFINERY.—The annual report for 1951 issued by the Societe Generale des Huiles de Petrole B.P., the French associates of the Anglo-Iranian Oil Company, states that the annual production of the new Dunkirk refinery will include 400,000 tons of motor spirit, 300,000 tons of gas oil, 900,000 tons of fuel oil, 100,000 tons of bitumen and 55,000 tons of lubricating oils. The plant consists of two atmospheric topping units, with a total distilling capacity of 6000 tons per day, one 1400 tons per day vacuum unit, one thermal reformer, rated at 850 tons per day, one Furfural extraction unit, with a daily production of 350 tons, and a 280 tons per day propane de-asphalting plant.

CLAYTON FELLOWSHIPS AND GRANTS, 1952.—Under the terms of the Clayton Bequest, the Institution of Mechanical Engineers has made the following awards for special experience, post-graduate studies, or research in mechanical engineering. The awards amount in total value to about £5200 for the year 1952. The successful candidates were; Clayton Fellowships—Mr. B. J. Beale, Mr. J. R. Botterill, Mr. F. J. Feltoe, Mr. E. J. Forster, Mr. P. M. Moreton, Mr. C. E. H. Morris, Mr. D. J. Myles, Mr. H. Naylor, Mr. J. R. Willetts, and Mr. R. G. Woolacott. Clayton Grants.—Mr. C. K. Gulland, Mr. J. R. Plant, Mr. J. L. Raynes, and Mr. T. F. Roylance.

IRON AND STEEL INSTITUTE.—A special meeting of the Iron and Steel Institute is to be held in Swansea on Tuesday, Wednesday and Thursday, October 7th, 8th and 9th. On the first day members and their ladies are invited to visit the Trostre tinplate works of the Steel Company of Wales, Ltd., and in the evening to attend a reception by the Mayor of Swansea, in the Brangwyn Hall. On Wednesday, October 8th, the Margam and Abbey Works of the Steel Company of Wales, Ltd., will be visited, and in the evening there is to be a banquet and dance at the Brangwyn Hall. The programme for the final day of the meeting, Thursday, October 9th, includes excursions to Llanwrtyd Wells or Tenby, or works visits in the morning and afternoon coach excursions to Gower and the Vale of Glamorgan.

1000kW MARINE GAS TURBINE SET.—Our attention has been drawn by W. H. Allen, Sons and Co., Ltd., to a mis-statement in our article under this title in our issue of August 1st, page 155. We referred to the combustion equipment as "standard Lucas aeronautical equipment which was not designed for the fuel at present being consumed by the turbine (diesel oil B.310)." In fact, the combustion chambers were designed for B.310 oil. They have proved entirely satisfactory since the very first run. We also remarked in discussing governor characteristics that under rich accelerating conditions "there is evidence in the exhaust that a considerable portion of (the) fuel is not actually burned." This was an exaggeration. Only a trace of haze is visible in the exhaust under those conditions.

REFRESHER COURSES FOR WORKS AND PLANT ENGINEERS.—The refresher courses for Works and Plant Engineers initiated by the Education Committee of Incorporated Plant Engineers have been held in past years at Bristol, Nottingham and Birmingham. These courses are designed to advance the present level of industrial efficiency and productivity by promoting the application of up-to-date techniques in works engineering practice over a wide field, as well as a long-term purpose of raising still higher the standards of plant engineering in this country. The Education Committee now announces that it has organised further courses to commence in the autumn at Glasgow and Liverpool. At each of these centres the course will consist of twenty lectures, given at weekly intervals by specialists drawn from industry and each will be followed by discussion. Brochures describing the courses will shortly be available and can be obtained from the general secretary of the Incorporated Plant Engineers, 48, Drury Lane, Solihull, Birmingham.

ATOMIC TESTS.—It was announced in May that the three Services and the Ministry of Supply would carry out a joint operation to test Britain's atomic weapon. Since then a special squadron carrying the scientific staff and test equipment has sailed for Australian waters. The imminence of the first test is indicated by an Admiralty announcement that an area of over 20,000 square miles lying off the north-west coast of Australia would be dangerous to both ships and aircraft. As defined, the area is roughly triangular in shape, distant, at its nearest point, about 25 miles from the port of Onslow, and includes the uninhabited limestone and coral Monte Bello Islands.

Personal and Business

ANGLO-IRANIAN OIL COMPANY, Ltd., states that Mr. J. A. Jameson, C.B.E., who has been a director since 1939, has retired from the board.

THE MINISTRY OF TRANSPORT announces that Captain A. C. W. Goodey, the senior nautical surveyor at Liverpool, is taking up a similar appointment at Belfast.

GUEST, KEEN AND NETTLEFOLDS, Ltd., announce that Mr. Reginald Catlow and Mr. Harry Ferguson Hodgson have been appointed directors of the company.

ENFIELD CABLES, Ltd., announces the appointment of Mr. G. E. Godfrey, A.M.I.Mech.E., as managing director of its subsidiary company, Brynmawr Rubber, Ltd.

BRITANNIA BATTERIES, Ltd., states that its London sales office has been moved to 53, Victoria Street, S.W.1 (telephone, Abbey 6168: telegrams "Britanicus, Sowest, London").

ELCONTROL, Ltd., manufacturer of industrial electronic equipment, has opened a factory at Wilbury Way, Hitchin. The sales department headquarters remains at 10, Wyndham Place, London, W.1.

JONES AND ATTWOOD, Ltd., Stourbridge, announces that it has acquired from the Mining Engineering Company, Ltd., Worcester, the sole manufacturing and selling rights of the latter company's bench power presses.

THE UNITED STATES LINES announces that Captain Harry S. Manning, the commodore of the company and master of the liner, "United States," has retired from active sea service, and has been succeeded as master by Captain John W. Anderson.

MR. A. R. DRIESSEN, O.B.E., Eastern Branch Manager of British Insulated Callender's Cables, Ltd., has been appointed commercial manager of the Indian Cable Company and he will leave for Calcutta at the end of the month to take up his new duties.

SIR ANDREW MACTAGGART has been appointed chairman of Balfour, Beatty and Co., Ltd., in succession to the late Mr. William Shearer. Sir Andrew has also taken Mr. Shearer's place as chairman and managing director of Power Securities Corporation, Ltd.

WHITE'S MARINE ENGINEERING COMPANY, Ltd., Hebburn-on-Tyne, states that Mr. G. Ridley Watson, M.I.N.A., M.I.Mar.E., London manager since 1935, has been appointed a director. Mr. Watson will continue at the firm's London office at 43, Billiter Buildings, 49, Leadenhall Street, E.C.3.

STANDARD TELEPHONES AND CABLES, Ltd., announces that the depot for its Newport cables division, which handles rubber, plastic and textile insulating cables and strip wiring cables, has recently moved from 7, The Side, Newcastle, to new premises at 21, Queen Street, Newcastle (telephone No.: Newcastle 20290).

MR. G. L. F. WELHAM, A.R.Ae.S., Production Development Engineer to the Fairey Aviation Company, Ltd., of Hayes, has been appointed deputy managing director to the Holbrook Machine Tool Company, Ltd., of Stratford, London, and Harlow, Essex. It is of interest to note that Mr. Welham's great-grandfather founded the original Holbrook factory about seventy years ago, and his father, Mr. F. Welham, who was works manager before retiring, served the same company for fifty-six years.

Launches and Trial Trips

RAEBURN, cargo liner; built by Harland and Wolff, Ltd., Belfast, for the Lamport and Holt Line; length between perpendiculars 435ft, breadth moulded 63ft, depth moulded to shelter deck 39ft 6in, gross tonnage 8000; one Harland-B. and W. single-acting, two-cycle, eccentric opposed-piston engine, seven cylinders 750mm diameter by 2000mm combined stroke, 112 r.p.m., three Harland and Wolff 200kW diesel generators. Launch, August 6th.

TWYFORD, cargo ship; built by John Lewis and Sons, Ltd., for Risdon Beazley, Ltd.; length between perpendiculars 200ft, breadth moulded 36ft, depth moulded 17ft 6in; one triple-expansion steam engine with cylinders 15½in by 27in by 44in diameter with a 27in stroke; steam supplied at 225 lb per square inch by an oil-fired Scotch boiler; two 60kW generators. Launch, August 7th.

MARWICK HEAD, self-trimming bulk cargo ship; built by Henry Robb, Ltd., for A. F. Henry and MacGregor, Ltd.; length between perpendiculars 250ft, breadth moulded 40ft, depth moulded upper deck 18ft 6in, depth moulded to raised quarter deck 22ft 6in, deadweight 2250 tons on 17ft mean draught, speed 10·5 knots; British Polar diesel engine, eight cylinders, 1280 b.h.p. at 250 r.p.m., two Ruston 100kW diesel generators, one Russell-Newbery 30kW diesel generator. Launch, August 7th.

British Patent Specifications

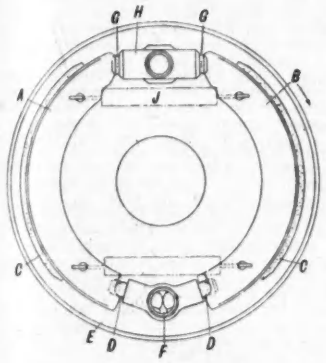
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ROAD TRANSPORT

675,579. July 9, 1949.—VEHICLE BRAKES, Girling, Ltd., King's Road, Tyseley, Birmingham, 11. (*Inventor: Gabriel Andrew George Fazekas.*)

In the brake illustrated in the drawing, *A* and *B* are two curved shoes carrying friction linings *C*. Stationary abutments for one end of each shoe are formed by the rounded ends of two tappets *D*, mounted to slide in an adjuster housing fixed on the stationary back plate *E* of the brake. The inner ends of the tappets engage with an adjustable cone or wedge *F* by which the tappets can be separated to take up wear of the shoe linings. The other ends of the shoes are engaged and separated to apply the brake by the pistons *G* of a double-ended hydraulic wheel cylinder *H*. The shoes are held in engagement with the pistons and tappets by tension springs *J* anchored to the shoe webs. According to the inven-



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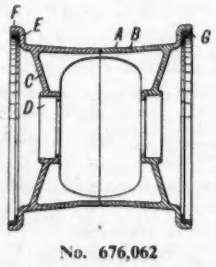
tion, the part of the end of the shoe web on the inner side of the engagement with the tappet is cut away so that the tappet engages with a curved surface on the outer side of the tappet only. The shoe is thus free to rock on the anchorage formed by the end of the tappet and to slide outwards on the anchorage, but is prevented from moving inwards. Thus, when the brake is applied with the drum rotating in the direction indicated by the arrow the anchored end of the shoe *B*, which is a leading shoe, is free to slide outwards on its anchorage, but the shoe *A*, which is a trailing shoe, is prevented from moving bodily towards the actuating cylinder *H*. A modified design is also shown in the specification.—*July* 16, 1952.

676,062. September 6, 1950.—REINFORCED WHEELS OR RIMS FOR TYRES, The Wingfoot Corporation, 1144, East Market Street, Akron, Ohio, U.S.A.

The invention relates to wheels and rims having tyre-retaining flanges reinforced with rings of steel or similar material. The wheel is built up as shown



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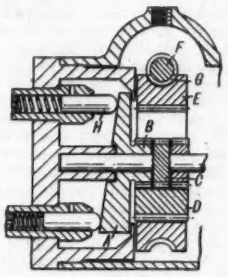
in the drawing with a supporting member *A* having a drum-shaped periphery *B* formed with integral spoke or disc portions *C* terminating in hubs *D*. The drum-shaped periphery of the wheel terminates at its ends in the integral tyre-retaining flanges *E* with integral lip or flange portions *F* positioned substantially parallel to the rotary axis of the wheel. The wheel is of the type adapted to be used on aircraft, and is usually cast from magnesium, aluminium, or alloys of these materials. Arranged concentric with the lip or flange *F* of the wheel is an endless ring *G* of reinforcing material, for example, high-strength steel, this ring not only being positioned snugly under the lip *F* to reinforce it, but usually engaging with the side of the tyre-retaining flange *E*. The ring is assembled by shrinking. Modified designs are also shown in the specification.—*July* 23, 1952.

PUMPS

675,754. April 6, 1948.—RECIPROCATING PUMPS, John Gane Shirley Barrow and Michael Wentworth Ewart-Wentworth, 44, Montrose Place, Chapel Street, London, and 2, New Square, Lincoln's Inn, London, W.C.2, respectively. (*Inventor: Robert William Eadie.*)

The invention relates to pumps with a number of pistons actuated by a cam drive, its object being to provide an improved construction having a very high reduction gear. In the drawing *A* is a cam fast to a pinion *B* and loosely mounted on an axle which is made fast to the casing and carries a fixed pinion *C*. *D* is a planetary pinion which engages with the outside of pinions *B* and *C* and with the inside of an annulus *E* provided with internal teeth and driven by means of a worm *F* engaging on gearing *G* on its



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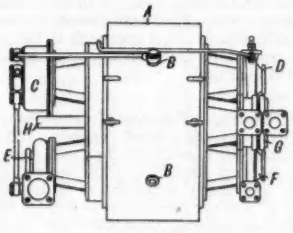
outer circumference. *H* are pistons actuated axially in cylinders by the rotation of the cam. Only one cam is shown, but a second cam could be made to operate another set of pistons. An alternative design with planetary instead of worm gearing is also shown in the specification.—*July* 16, 1952.

675,782. December 25, 1949.—PUMPING INSTALLATIONS, Drysdale and Co., Ltd., Bon-Accord Works, Yoker, Glasgow; and Charles Henderson Carslaw, of the company's address.

The invention relates to pumping installations with a number of pumps supplying a variety of liquid or vapour services, such as a marine distiller which may require a salt water pump, a fresh water pump, a brine pump and a vacuum pump, in simultaneous operation. In the drawing *A* is a housing enclosing the rotors and stators of three electric motors and formed with water passages surrounding the motors, and *B* the water connections to the water passages. *C* is an air pump of the water ring type connected to one end of the rotor of one of the electric motors, and *D* is a fresh water pump connected to the other end of the same rotor. *E* is a circulating water pump



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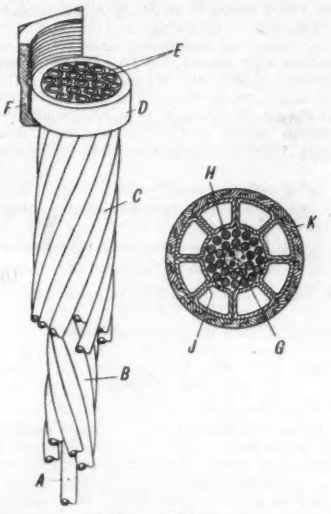
connected to one end of the rotor of a second electric motor, and *F* a brine pump connected to the other end of the same rotor while *G* is a coil drain pump connected to one end of the third electric motor, the shaft *H* at the other end of the rotor protruding through the housing *A* and being fitted with a protecting hood so that it is readily available for connecting to other apparatus, such as a starch injection pump.—*July* 16, 1952.

MISCELLANEOUS

676,224. May 14, 1949.—FLEXIBLE PIPE-LINE CONSTRUCTIONS, Harald Schulze, 325, Widdersdorferstrasse, Koln-Braunsfeld, Germany.

The invention concerns flexible pipe-lines for conveying gaseous or liquid fluids under high pressure, and methods for making the pipes. According to the left-hand drawing, the flexible pipe-line has one pipe *A* constituting the core, which is surrounded by similar pipes in the form of clockwise or counter-clockwise helices and having circular cross sections, the pipes being arranged in two layers *B* and *C*. All the pipes are kept together by means of the coupling, made in the form of the reinforcing ring *D*, the spaces *E* between the pipes and the ring being filled by brazing material connecting them rigidly with the ring. Pipe sections can be easily coupled by a union nut *F* or by other means. According to the right-hand



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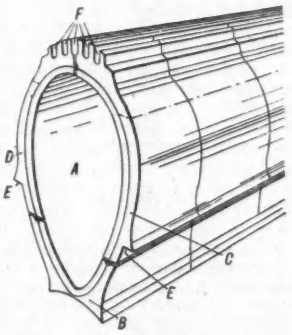
drawing, the core *G* of the pipe-line consists of a three-core electric cable, the wires being embedded in a common insulating mass. The core is surrounded by a reinforcing unit or insert *H* comprising a number of round wires or metallic conductors, and it is this cable that is surrounded by a layer *J* of individual pipes helically wound round the core. The cross-section of every pipe is a trapezoid and the pipes join tightly and are well supported by the carrying cable. The reinforcement consists of steel wires *K*, adjacent wires engaging one with the other in overlapping relationship by means of complementary flange portions and recesses at the sides, thus protecting the pipes against high fluid pressures and preventing the outer surface of the pipes being damaged.—*July* 23, 1952.

CIVIL ENGINEERING

675,616. February 28, 1950.—DRAIN PIPES, Frantisek Hlavka, Castle Donington, near Derby.

In the drawing the egg-shaped bore *A* is defined by a pipe which is assembled in three separate segments, a bottom portion *B* and two upper portions *C* and *D*, joined together. External flanges *E* are provided to enable the pipes to be lifted. On the top of the pipe are grooves or channels *F*, in which



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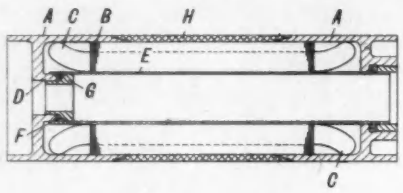
pipes or cables can be laid. The egg-shaped form of the pipes anables them to withstand heavy weights and external pressures, and the narrow bottom part serves to cause liquids to flow more quickly to remove sediments and reduce the settlement of solid materials. In addition, the broader upper part of the pipe which supports the external pipes or cables enables a saving of manpower and expense, as one excavation for the drain pipe will serve also to carry the other services.—*July* 16 1952.

ELECTRICAL ENGINEERING

675,602. December 19, 1949.—THE CONSTRUCTION OF STATORS FOR DYNAMO-ELECTRIC MACHINES, Chance Brothers, Ltd., Glass Works, Smethwick, 40, Near Birmingham (*Inventor: Louis Bertram Henry Hallett*).

The invention applies particularly to submersible motors. It comprises a construction in which the outer shell of the stator is formed by a pair of preformed end covers and an intermediate part which is

formed by metal spraying. As shown in the drawing, there are a pair of preformed end covers *A* of such length that they can overlap the ends of and be supported on the cylindrical laminated structure *B* carrying the windings *C*. The portions of the end covers which extend over the laminated structure are preferably tapered externally, and the tapered surfaces may be ridged or roughened to effect an intimate connection with the part to be applied by spraying. On the inner side of one of the end covers is formed a hollow central boss *D* over which can be slipped one end of the tubular lining *E*. The boss is provided with an annular rubber seal *F* for ensuring a watertight connection between the lining and boss, the seal being



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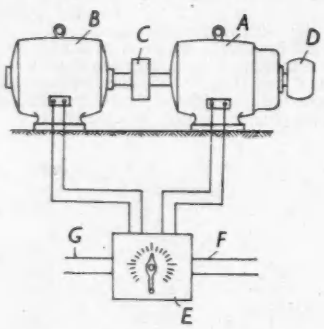
held in position by a bush *G* in screw-thread connection with the boss. The other end cover is formed with a hollow central boss which embraces the other end of the lining *E*, and is also provided with a sealing ring held in position by a bush. In assembling the stator parts, the end covers are first placed over the ends of the wound laminated structure and windings, and the lining may also be inserted at this stage. With the end covers in position the greater part of the outer peripheral surface of the laminated structure is at this stage exposed. To complete the outer shell of the stator, any convenient metal is then sprayed on to the exposed surface of the structure *B* and on to the tapered ends of the end covers *A*, the spraying being continued until a sufficient thickness of metal *H* has been deposited.—*July* 16, 1952.

676,132. February 9, 1950.—VARIABLE-SPEED POWER UNIT INCORPORATING TWO A.C. MOTORS, William Arthur Nelson, of Nelbest Works, Main Street, Mossend, Bellshill, Lanarkshire.

The invention concerns a variable-speed power unit incorporating two a.c. motors, intended primarily to provide a large range of speed control from creeping speeds to speeds in excess of the normal operating



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speed. In the accompanying drawing *A* is an a.c. slip-ring induction motor coupled by a shaft to a second a.c. motor *B*, which has at least one operating speed in excess of the operating speed of the motor *A*. *C* is an off-position brake operative on the shaft and *D* is the power take-off pulley. *E* is a controller electrically coupled to the two motors. *F* denotes the leads conducting alternating current to the controller *E* and *G* the leads conducting direct current to the controller. When the load is to be operated at speeds varying from creeping speeds up to the operating speed of the motor *A*, the control means *E* is set to apply alternating current to the motor, and the speed of that motor is adjusted in the usual manner by the control means. Additional control of the speed is provided by setting the control means to apply direct current to the stator of the motor *B*. This motor then operates as an eddy current brake, the braking torque of which is variable according to the voltage of the applied direct current, and to the external resistance in the motor circuit. For speeds in excess of the operating speed of the motor *A* the control means *E* is set to apply alternating current to the motor *B*, and to switch off the motor *A*. The speed provided by this arrangement will be any of the operating speeds of the motor *B*. The off-position brake *C*, operative on the shaft connecting the motors, serves to prevent the load to which the motors are connected from rotating them.—*July* 23, 1952.

Technical Reports

The Effect of Cold Drawing on the Creep Resistance and Structure of 0·5 per cent Molybdenum Steel Steam Piping (Ref. J/T154). By E. A. Jenkinson, M.Sc., A.I.M., and D. C. Herbert, B.Sc. (Eng.), A.I.Mech.E. The British Electrical and Allied Industries Research Association. Price 7s. 6d., postage 3d.—As it was considered that the use of cold drawn pipes, having smooth surfaces, would be a precaution against failures due to cracking in service which occurred some time ago, tests were carried out to determine how cold drawing might affect the creep resistance and graphitisation of the steels. The work was done at the National Physical Laboratory. The results are given in the report, from which it can be concluded that cold drawing to improve surface finish does not cause any deterioration in the creep resistance of the steel provided that the pipes are normalised after cold drawing.

Oil Circuit Breakers: Pressure Set Up by Sudden Increase of Fault Current in an Arc Control Pot (Ref. G/T249). By W. B. Whitney, H. W. Baldrey and A. E. Helden. The British Electrical and Allied Industries Research Association. Price 18s., postage 4d.—This report describes the results of experiments carried out to determine pressure likely to be set up in an h.t. arc control pot (of type described) under the somewhat rare operating conditions in which a long low-current arc suddenly develops into a long high-current one due to occurrence of a short circuit at a later stage in arcing. In addition to giving the experimental results, the report describes the development of formulæ and graphical methods for calculating the pressure set up in the pot under other conditions of circuit voltage and current than those used in the experimental work.

The Equivalent Circuit of the Capacitor Transformer (Ref. Q/T119). By M. Waters, B.Sc., A.M.I.E.E. The British Electrical and Allied Industries Research Association. Price 4s. 6d., postage 3d.—Previous reports, Ref. Q/T104 and Q/T108, have shown how to design capacitor transformers to comply with given performance data. The present report shows that for a given design the performance may be determined from a simple equivalent circuit which is similar to that of an ordinary transformer. There are two main points of difference: first, the excitation current is capacitive instead of inductive, and, secondly, the variation with frequency of the equivalent series reactance is much greater than that of a transformer.

The Calculation of Currents Due to Faults Between Turns in Transformer Windings (Ref. Q/T121). By B. L. Coleman, B.Sc. The British Electrical and Allied Industries Research Association. Price 6s., postage 3d.—A method of calculating the fault current drawn from the line on the occurrence of a fault between turns has been given in a previous report (Ref. Q/T103) for a single-phase transformer wound on one limb. The result is now extended to a single-phase transformer wound on two limbs and to the simpler three-phase transformer connections. The present report is a first approach to the problem and deals only with faults in the winding which is connected to the supply.

On the Torsional Vibrations of Long-Chain Molecules—I (Ref. L/T266). By B. Szigeti. The British Electrical and Allied Industries Research Association. Price 9s., postage 3d.—Simplified models are discussed for long-chain molecules in which all units are equal except for one which is heavier than the others. Certain general conclusions are reached for the vibrations of such molecules. The work was done at Liverpool University. The results will be applied to the out-of-plane or torsional vibrations of long-chain ketones in a subsequent publication.

The Torsional Polarisation of Long-Chain Molecules—II (Ref. L/T267). By B. Szigeti. The British Electrical and Allied Industries Research Association. Price 4s. 6d., postage 3d.—Long-chain molecules are considered in the extended configuration, and the interaction between molecules is neglected. The out-of-plane vibrations consist of a superposition of a translational and a rotational motion; the relation between the amplitudes of these two is derived. For long-chain ketones, with the CO-group near the centre of the chain, the mean square amplitude of the torsional vibration of the CO-group is calculated. At any particular temperature this is approximately proportional to the chain length. The polarisability of ketones connected with the torsional vibrations is calculated and turns out to be very large compared with the usual effect of internal vibrations. Although this polarisability is contributed by harmonic internal vibrations, it nevertheless forms part of that term in the total polarisability which is usually called the orientational polarisation. The work on which the report is based was done at Liverpool University.

Contracts

LINEA AEROPOSTAL VENEZOLANA (L.A.V.) and the de Havilland Aircraft Company jointly announce that two Series 2 "Comet" jet airliners with Rolls-Royce "Avon" engines have been ordered by the air-line for use on a direct non-stop express service between Caracas and New York. Delivery of the aircraft is expected in the middle of 1955.

SIMON-CARVES, Ltd., Cheadle Heath, Stockport, has received from the North Eastern Division of the National Coal Board a contract for the construction of coke ovens, by-product plant, and coal and coke handling equipment at Manvers Main colliery in Yorkshire. A new battery of sixty-six ovens is to be built on a new site; twelve new ovens are to be added to the existing coking plant, and fourteen of the existing ovens are to be rebuilt. The new by-product plant will handle the gas from the whole of the new battery and twenty-seven of the existing ovens.

DURING the past month the British Electricity Authority has placed contracts for equipment for power stations, transforming stations and transmission lines, amounting in the aggregate to £12,629,687. The principal contracts include: Cowes power station, two 135,000 lb per hour boilers (Daniel Adamson and Co., Ltd.) and steel frame for office block, turbine house and boiler house (Peirson and Co., Ltd.); Goldington power station, Bedford, two generator transformers (Hackbridge and Hewittic Electric Company, Ltd.); Tilbury power station, precipitator casings (Bierrum and Partners, Ltd.) and steel frame buildings (Alex. Findlay and Co., Ltd.); Drakelow power station, Burton-upon-Trent, coal handling plant (Mitchell Engineering, Ltd.); Northampton power station, two 150,000 lb per hour boilers (Bennis Combustion, Ltd.); Meaford "B" power station, Stone, Staffs. one cooling tower (Davenport Engineering Company, Ltd.); Bold power station, St. Helens, Lancs. one cooling tower (Film Cooling Towers, Ltd.); Connah's Quay power station, near Flint, superstructure to power station, south block and ancillary buildings (J. Gerrard and Sons, Ltd.); Ince power station, near Ellesmere Port, ash and dust handling plant (Babcock and Wilcox, Ltd.); Doncaster power station, structural steelwork (Wright, Anderson and Co., Ltd.); Skelton Grange power station, Leeds, 3300V and 415V switchgear (English Electric Company, Ltd.); Stella North power station, near Newcastle upon Tyne, foundations for main and ancillary buildings (Sir Robert McAlpine and Sons, Ltd.), three 60MW turbo-generators, condensing and feed heating plants (C. A. Parsons and Co., Ltd.), and low pressure piping equipment (Aiton and Co., Ltd.); Stella South power station, four 60MW turbo-generators, condensing and feed heating plants (C. A. Parsons and Co., Ltd.); Chadderton power station, Oldham, one cooling tower (Fred Mitchell and Son, Ltd.); Clyde's Mill power station, Glasgow, foundations for extensions (Holst and Co., Ltd.); Carrington sub-station, near Manchester 90MVA, 132kV, oil-filled reactors (Hackbridge and Hewittic Electric Company, Ltd.); Staythorpe to Elstree, 275kV twin 0·4 square inch overhead line (British Insulated Callender's Construction, Ltd.); and Llantarnam to Crumlin, Monmouthshire, 132kV overhead line (J. L. Eve Construction Company, Ltd.).

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX

Fri. to Mon., Sept. 19th to 22nd.—The Hayes, Swanwick, Derbyshire, Conference on "Information Service: Theory and Practice."

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Wed. to Wed., Sept. 3rd to 10th.—Annual Meeting in Belfast.

ENGINEERS' GUILD

Thurs., Sept. 25th.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., Sept. 4th—SOUTH YORKSHIRE BRANCH: Evening visit to Lady Bower Dam, 7.15 p.m.

Thurs., Sept. 11th.—NEWCASTLE UPON TYNE BRANCH: Roadway House, Newcastle upon Tyne, "Liquid Fuel Firing," Alan Moore, 7.30 p.m.

INDUSTRIAL WELFARE SOCIETY

Thurs. to Sat., Sept. 4th to 13th.—Keble College, Oxford, Third Annual Conference for Apprentices, Theme: "The Approach to Industrial Responsibility."

INSTITUTE OF FUEL

Tues. and Wed., Oct. 28th and 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Conference, "A Special Study of Ash and Clinker in Industry."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Oct. 1st.—Royal Society of Arts, John Adam Street, London, W.C.2, Annual General Meeting, 6.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Tues. to Thurs., Sept. 23rd to 25th.—Imperial College of Science and Technology, Prince Consort Road, South Kensington, London, S.W.7, Symposium on Mineral Dressing.

INTERNATIONAL MACHINE TOOL EXHIBITION

Wed. to Sat., Sept. 17th to Oct. 4th.—Olympia, London.

IRON AND STEEL INSTITUTE

Tues. to Thurs., Oct. 7th to 9th.—Special meeting in Swansea.